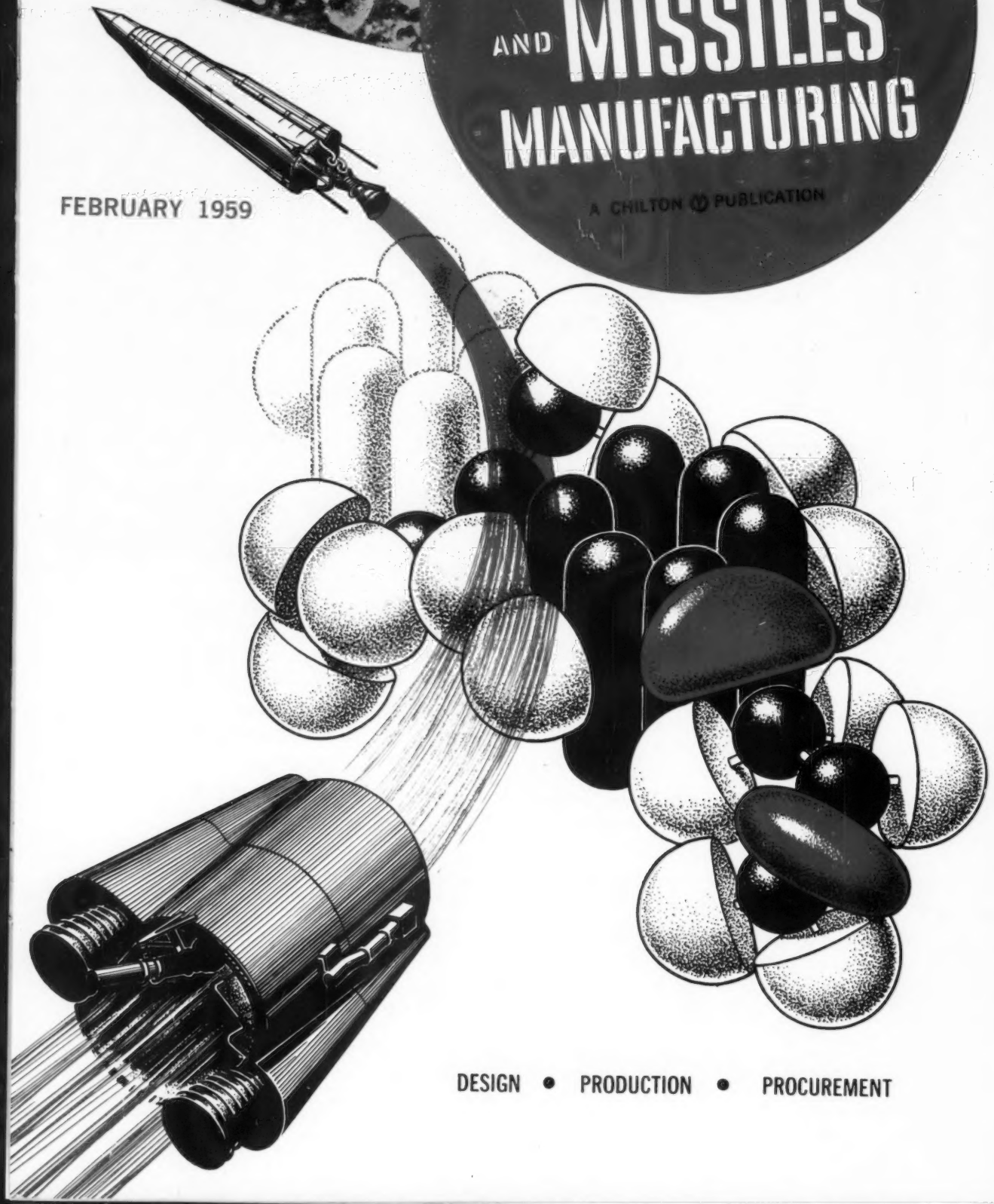
AIRCRAFT AND MISSILES MANUFACTURING

A CHILTON PUBLICATION

FEBRUARY 1959



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FEBRUARY 1959
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DESIGN
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THE COVER STORY

Nature has provided us with just over 100 elements. One of these elements, carbon, has been such a versatile building block that it serves as the basis of an entire field of scientific study, organic chemistry. The organics, as structural resins and as fuels, are providing aircraft and missiles with a capability that may take us beyond Earth to new elements and completely new concepts in the nature of matter.

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NEXT MONTH
Look for the Missile Handbook!

industry notes

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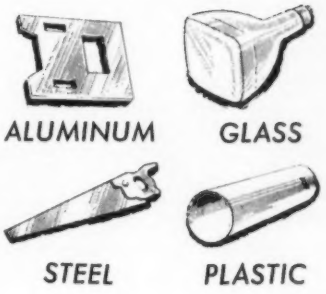

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Circle 5 on Inquiry Card, page 83

NASA sets fast pace

Twenty-one days after its formal establishment the National Aeronautics and Space Administration gave the industry a mild shock by announcing it was accepting bids for a manned satellite capsule. NASA Director T. Keith Glennan had his organization on the move.

A meeting was held at Langely Research Center in early November. Bidders were informed of project specifications. These specs were unusual; they spelled out in rather complete detail the actual design configuration of the capsule.

NASA allowed prospective bidders about one month to prepare proposals. Closing date was set at December 11.

In the ensuing weeks there was great speculation as to who would be awarded the sizable prestige contract. The space giants which began gathering high-priced engineering talent into their fold about two to three years ago formed "inter-company design teams." For example, General Electric MSVD and North American Aviation, who competed for a WADC space capsule design study (MSVD was awarded the contract), teamed. Self-assuredly, they told each other that the team was a "shoo-in." Others felt the same about themselves.

The giants were mildly jarred, when on January 12, alleged dark horse McDonnell Aircraft was awarded the contract on a purported $16 million bid. NASA apparently was not impressed by MSVD's reentry know-how gained in Thor and Atlas nose cones nor North American's physiological know-how gained in X-15 studies.

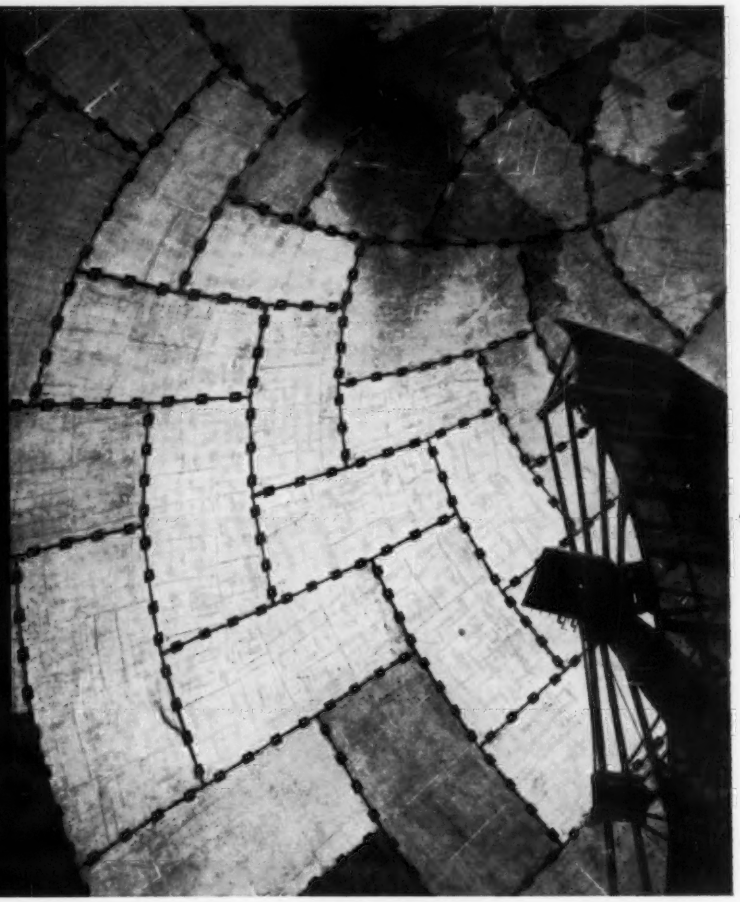
Now comes the crucial test, did NASA really know what it needed in terms as positive as the specifications? Is the engineering talent already possessed by the winner, or will this award trigger another of the familiar cross-country recruiting campaigns? A confusing pattern has evolved from recent contract awards and cancellations by Government agencies.

"Stable" engineers have in some cases thrown up their hands in despair. Others have become reconciled to chasing contracts cross-country to stay employed. Still others have taken advantage of the situation by job jumping, to promote sizeable salary increases.

Let us hope that NASA's choice will be consistent with Mr. Glennan's and his organization's farsightedness; rather than precipitate another geographic shift of engineering talent in our wavering space program.

Editor

stitching together a giant radome



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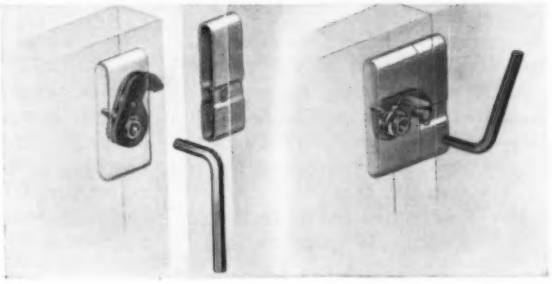

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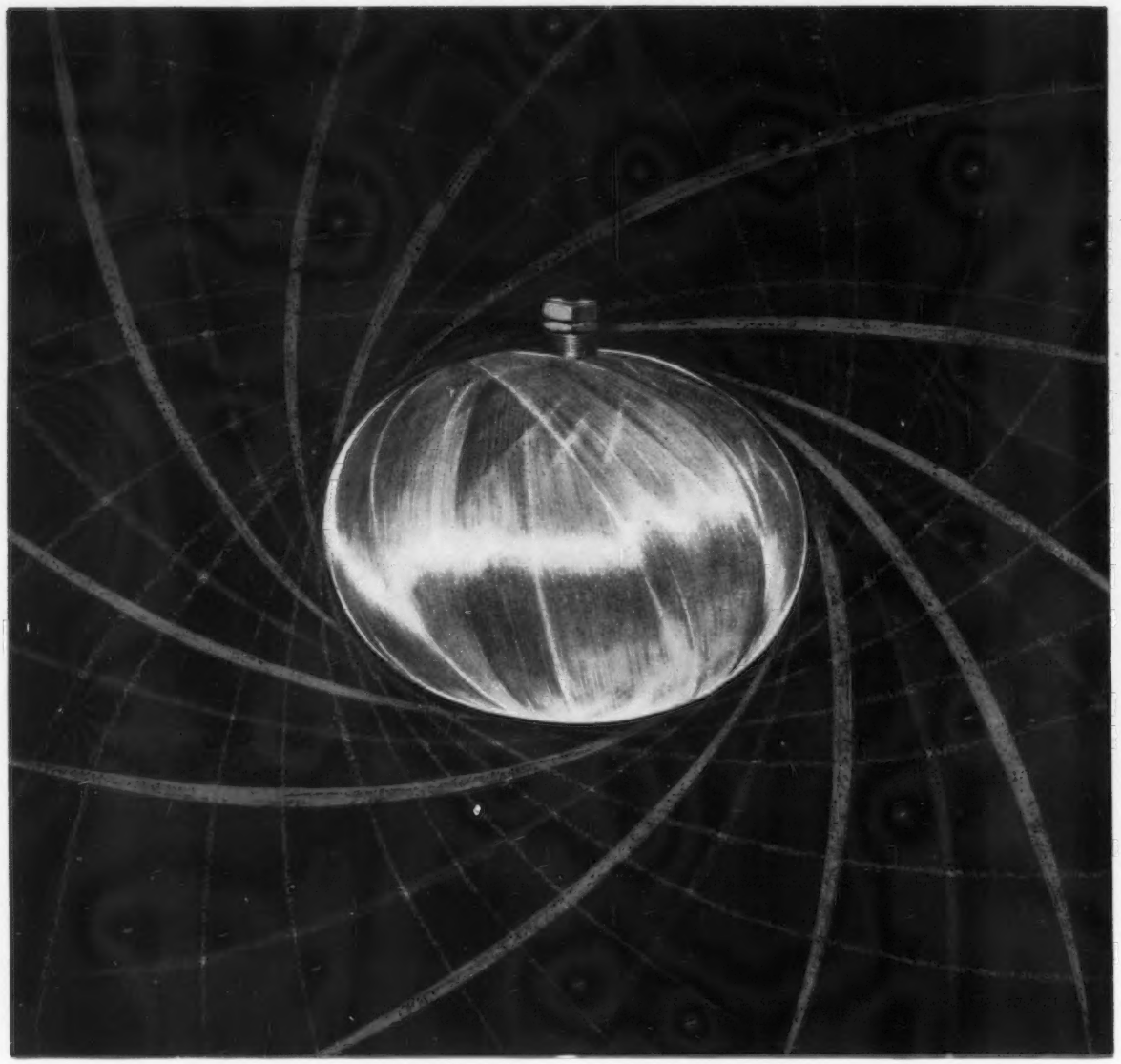

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Here's the big news in the pressure vessel field. Brunswick's new, unique Strickland "B" Process (SBP) now results in filament-wound plastic vessels with the greatest strengths ever obtained. At the same time, vessel weights have been drastically pared down. Brunswick can create vessels (from that shown above to air bottles and rocket motor cases) with these specifications: Hoop stress values in the range of 175,000 to 200,000 psi. Burst strength values: up to 150,000 psi. Weight: 20 to 40 per cent *less* than that of *any* previously built plastic vessels. Temperature limits: up to 600° F. Super tough SBP vessels are also ideal for components that must stand up to extended operating cycles, and can be mass produced in compound and monocoque shapes.

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MAKES YOUR IDEAS *WORK*

air conditioning Thor

portable, compact heating/cooling unit vital part of ground-support equipment; reliability enhanced by temperature control in measurement unit, guidance, and engine

by J. Philip Geddes

The need for controlled atmospheres inside large missiles has made air conditioning units a necessary part of standard, ground support equipment.

In measurement units for liquid fueled rockets, this need is demonstrated by the fact that units must be kept in stable atmospheric environments from the time of delivery by the manufacturer to final countdown. On the Thor, for example, a three minute shut down of the measurement unit air conditioning system means optically recalibrating the unit before the missile is operational again. Likewise guidance sections, with their sensitive gyros, cannot be subjected to extreme temperature variations without affecting performance.

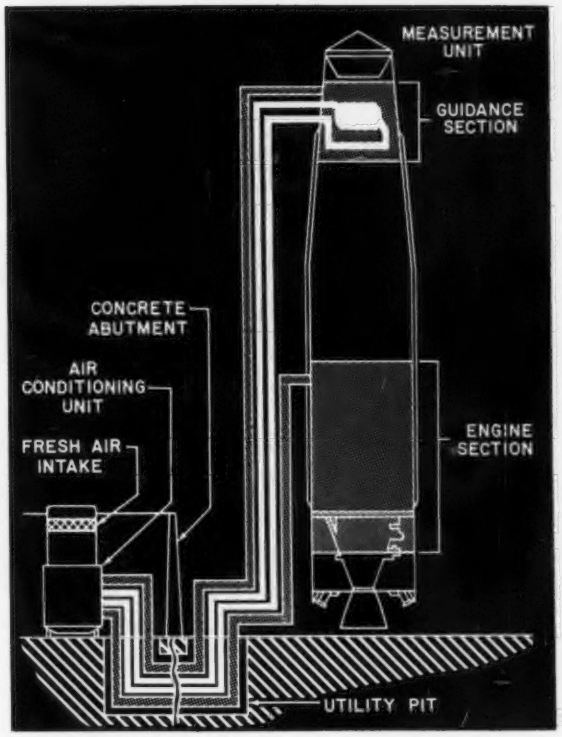
Ground heating/cooling requirements for present liquid fueled missiles vary from missile to missile, and even from section to section within a particular missile. Ground-support air conditioning units must therefore be reliable, automatic, mobile, and flexible enough in operation to satisfy precisely the demands of each section.

Thor Air Conditioner

The scope of the ground air-conditioning problem is illustrated by studying the support unit used for the Thor.

Designed and built by C. G. Hokanson Co., Inc., to Douglas specifications, the unit consists of three separate operational systems. All are integrated and mounted on a single mobile chassis. The three systems are:

- Measurement unit system, which provides continuous heating and cooling during storage, standby, and countdown.
- Guidance section system, which provides heating and cooling during countdown only; changes to cooling cycle before firing by remote control.
- Engine section system, which provides heating during countdown only; changes to high speed operation for nitrogen purge.



Schematic shows physical layout of ground-support air conditioning unit for Thor IRBM. Longest ducts are 150 ft; ducts remain in place until instant of launch. Separation is by auto-quick-disconnect.

Temperature is controlled from the missile in the first two systems, from the air conditioner in latter system. Air connections to the missile are made through four ducts, three outlets and one return. Each is approximately 150 feet long.

continued on next page

air conditioning Thor . . . continued

Measurement Unit System

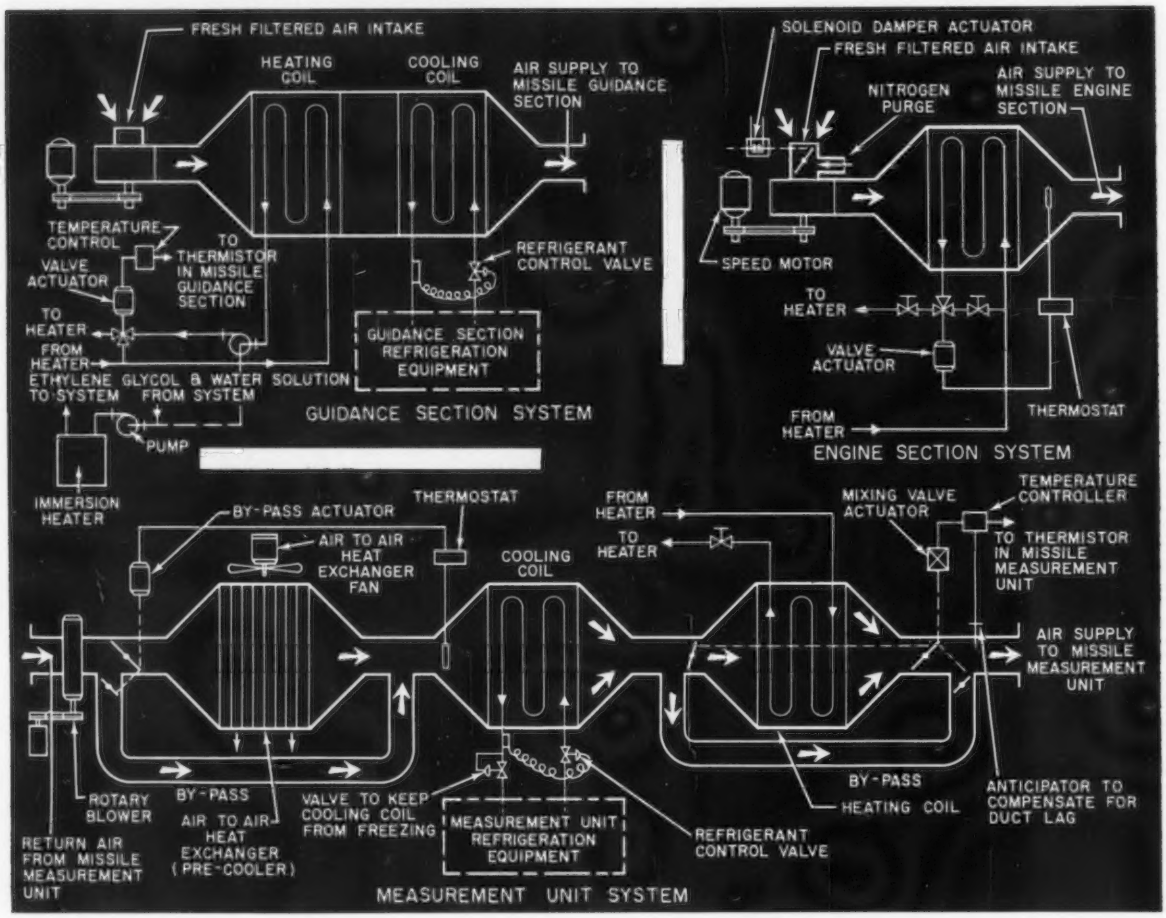
Two hundred cfm of 100 per cent recirculating air is delivered through 3 in. ducting against 60 in. H_2O static pressure in the measurement unit system. Temperature control is from a thermistor sensing element in the missile about a control point of 90°F ± 2°F. A warning signal to the countdown control station, and a red light on the unit are automatically energized should temperature go out of control band. System has 15,000 btu/hr cooling capacity and 25,600 btu/hr heating capacity. An air to air heat exchanger is incorporated to reduce refrigerant compressor operating time.

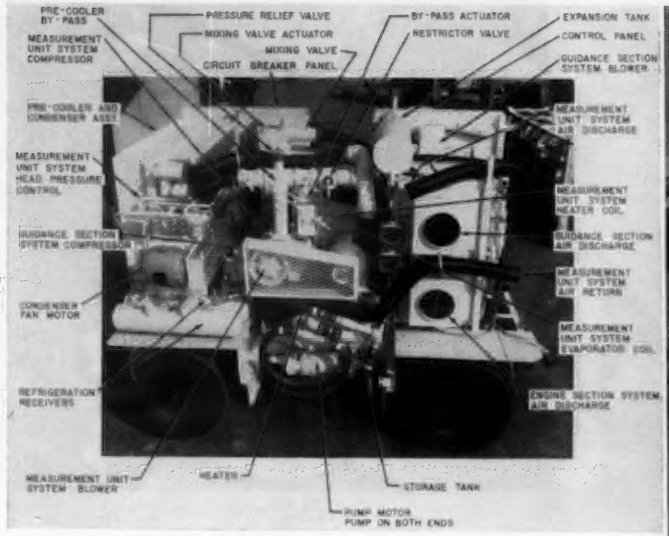
Return air from the missile enters the air conditioner and is driven by a positive displacement blower into an air-to-air heat exchanger. This serves as a precooler for the second cooling stage. (A proportion of the return air is also bled through a bypass duct around the heat exchanger. The proportion of uncooled air passing through the duct is governed by the position of the duct mixing valve, which holds duct exit temperature to approximately 75°F.) Second cooling stage consists of a duct wound in a series of cooling coils. The cooling coils form a part of a Freon 12, vapor cycle refrigeration system. Flow leaving the second cooling stage is maintained at 45 ± 5°F to lower the dew point, and also provide some cooling. Should the measurement unit demand air above 45 ± 5°F, a portion of the air is passed through a heating stage. A mixing valve/by-pass duct combination controlled by the missile thermistor regulates the final temperature of the air passing to the missile.

Guidance Section System

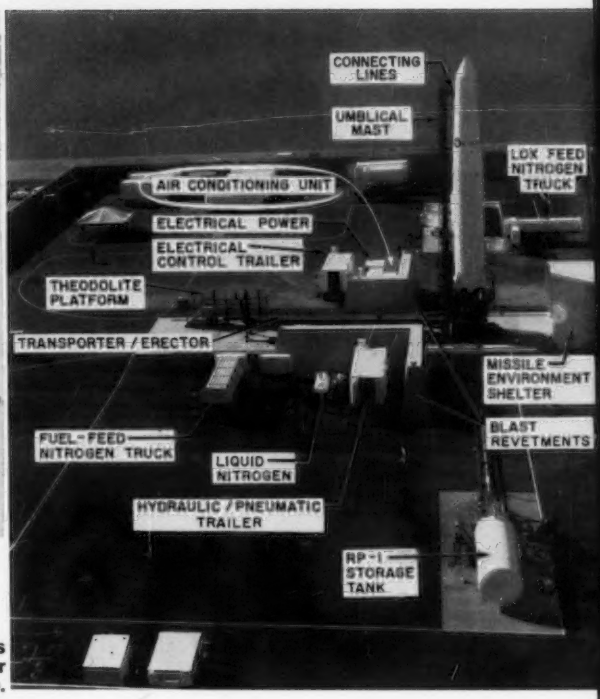
Eight hundred cfm of fresh air is delivered through 8 in. ducting against 13.5 in. H_2O static pressure to control temperatures in the guidance section. Temperature control is from a thermistor

Complete Thor unit consists of three systems. Engine section system supplies only heating. Others supply heating and cooling. Two pumps are used to circulate heating liquid (50-50 mix of ethylene glycol and H_2O).





Designed and built by C. G. Hokanson Co., Inc., to Douglas specifications, air conditioner for Thor mounts its three systems on one compact, mobile trailer.



Layout of Thor launching pad shows some of ground equipment. Air conditioner is behind revetment near missile. Units in background are spares.

sensing element in the missile. Supply air-blower turns on when missile temperature is 80°F. Refrigerant cooling system operates when missile temperature drops below 45°F. Should missile temperature drop below 33°F or exceed 124°F a warning system is actuated. System has 36,000 btu/hr cooling capacity and 200,000 btu/hr heating capacity.

Engine Section System

One thousand cfm of fresh air is delivered through 8 in. ducting against 13.5 in. H_2O static pressure to heat the engine section. Temperature is controlled at the air conditioner and can be regulated between the range of 40 to 200°F. Air is exhausted from the trailer to the missile at the desired temperature ±10°F. Blower is operated by two speed motor. An automatic signal from the missile starts and selects blower speed. Another automatic signal closes the air intake shutoff for the system, to allow a prelaunching nitrogen purging charge to be introduced into the system. A warning signal actuates should missile temperature drop below 5°F. System has 225,000 btu/hr heating capacity.

Heating Provisions

Heat for the three systems is generated in a compact electric fluid immersion heater. The heater is divided into three 25 KW stages. Temperature is controlled by a ambient-temperature reset three-stage thermostat. With ambient temperature at —65°F, water leaving the heater is at 190°F, and with ambient temperature at 125°F water leaves the heater at 140°F. Heating system fluid, consisting of 50 per cent ethylene glycol and 50 per cent distilled water, is circulated to the three systems in the trailer by two pumps. One pump serves the engine section, and measurement unit systems; the other serves the guidance section system. Forced circulation with two pumps results in more accurate temperature control.

General

The measurement unit system specification calls for non-stop operating time of 500 hr, the engine section system for 100 hr at high speed and 300 hr at low speed, and the guidance section for 200 hr. Overhaul time for the complete trailer unit is after 10,000 hr operation.

Reliability is enhanced by built-in test devices which allow monitoring of components not in continuous operation. Also, each trailer unit is tested in a simulated field environment before delivery.

A REPRINT
of this article can be obtained by writing on company letterhead to
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Poor quality and improper routing of wires would have made component at left unreliable or short-lived. At right, the same component is seen after vendor re-routed wires to avoid abrasion problems and increase durability.

reliability's weakest link

small functional components often cause vehicle failure, Convair's "grass roots" quality control keeps primes, vendors, customers out of trouble

by Kent Sinclair, supervisor, receiving inspection, Convair-San Diego

First-article inspection form, used in receiving inspection, incorporates 22 items to be checked and recorded on this form.

FIRST ARTICLE INSPECTION Engineering_____

Part Number_____ Purchasing _____

1. ( ) Check dimensionally all external dimensions per
   ( ) Vendors Drawing No. _____ Ltr. Chg. ___
   ( ) Specification No. _____ Ltr. Chg. ___
   ( ) Convair Drawing No. _____ Ltr. Chg. ___
   ( ) ANA Bulletin No. _____ Ltr. Chg. ___
   ( ) Other

2. ( ) Moving Parts
   ( ) Clearance ( ) Min. ___ ( ) Max. ____

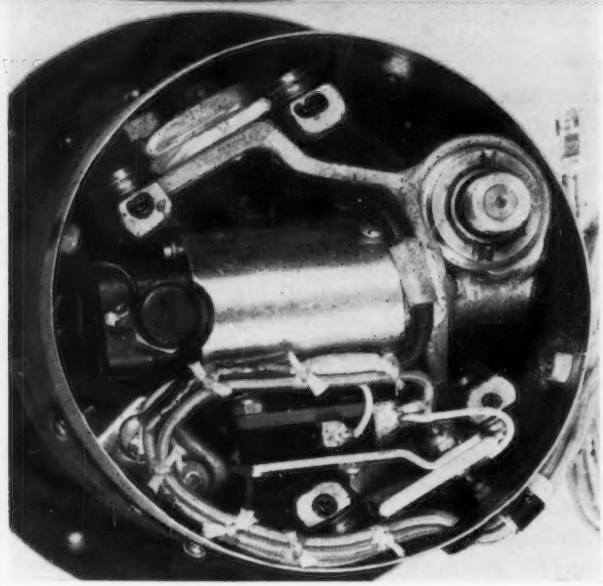
3. ( ) Workmanship
   ( ) Neatness of Ass'y. ( ) X Ray
   ( ) Burs (sharp edges)
   ( ) Marking of parts
   ( ) Contamination ( ) Dirt ( ) Chips ( ) Other
   ( ) _____

4. ( ) Unit filled with preservative oil.

5. ( ) Ports ( ) Total No. _____ AN ( ) MS ( ) Pipe ( )
   ( ) Size _____ ( ) Passages
   ( ) Flow Direction

The testing of aircraft functional components is big business at the Convair Division of General Dynamics Corp., San Diego. The aircraft involved are the F-102A Delta Dagger, the F-106 Delta Dart, the 880 and 600 Jet Liners. The functional-test inspection section here tests more than 30,000 parts each month.

A significant phase of this activity incorporates a dual-input, dual-output reliability improvement program. This program combines testing-personnel skill and standard quality control data gathering techniques. It utilizes the know-how of engineering specialists, functional-test inspectors and flight-line inspectors.



The benefits of the reliability program have been felt in several areas as follows:

- Engineering design groups have a greater assurance of receiving the type of components they need for designing reliable systems.
- Component vendors are kept informed on the performance of their products, through first-article inspection and continuous monitoring. They are assisted to increase the reliability of their products and raise their ratings where needed.
- Overall quality control costs are kept low by pin-pointing and eliminating component trouble spots early. This has reduced replacement of parts and decreased the number of engineering changes.
- The resulting increase in reliability of the end product, has promoted customer satisfaction.

Most vendors have their component subjected to a first-article test and evaluation in the receiving inspection functional-test area.

During the first-article test the vendor often has a representative present, usually a quality control man or engineer. Convair supplies an engineer from the design group concerned with the component, to assist functional test inspectors. In these tests specification compliance, dimensional conformity, quality of workmanship and functional performance are examined; component features are evaluated for conditions proven troublesome on similar parts in the past. Often, conditions corrected at this stage are seemingly insignificant, yet become potential sources of future trouble if neglected. Typical items of this type may include poorly secured wires, faulty insulation, improperly-soldered joints, absence of safetying means, presence of metal shavings and dirt, etc.

First input to the system is a program of data gathering. No matter how thorough the first inspection, not all bugs may be discovered during first-article inspection. Receipt of a vendor's production-run component starts a chain of data collection; this acts as a continuous display of reliability and culminates in the publication of a VQR (Vendor Quality Rating).

Data collection on incoming shipments of components is accomplished through use of five types of control forms to be discussed below.

Vendor's Approval Form

This is issued by the purchasing department which plainly states that Vendor XXX has had his drawing #XXX-X approved by Convair engineering to be supplied as part #XX-XXXX-XX.

Functional-Test Instruction

This is the actual functional-test procedure to be used by the test inspector. The instruction contains information as to test media, equipment, and conditions required, also detailed steps of the functional test. Acceptable operating limits are supplied by design engineering to quality control; quality control incorporates these limits into the language of the test equipment and the test inspector.

The functional-test instruction insures that all components of a specific part number receive identical functional tests, regardless of operator. This form, which is approved by engineering, is available to the component vendor to show the parameters of operation expected of his part; it also enables him to evaluate rejected items and aids in the asymptotic approach to test compatibility.

Inspector's Rejection Form

This is a more or less standard material review form. Cross referenced on the serially numbered inspector's rejection is the Convair part number and vendor's part number. The inspector's rejection shows the exact portion of the functional-test instruction which the component failed to pass. Copies of the rejection go to purchasing and quality control statistical groups.

Historical Record

This form, maintained in receiving inspection, shows the total quantity of each lot and the number accepted or rejected.

continued on next page

Vendor Quality Rating

This is a statistically accumulated rating which gives a numerical rating to each vendor. This rating is based on the ratio of observed per cent defectives compared with the maximum allowable per cent defectives.

These control forms constitute the first input to the dual-input inspection functional-test group. This group has at hand an up-to-the-minute picture of reliability of any given component.

Excessive rejection of a lot triggers off an investigation, at receiving inspection, to determine the cause. Often the analysis of the test data results in design changes to the component.

Unsatisfactory test-data motivate quality control to contact vendors with low ratings to assist them in raising their ratings by analysis of rejection causes. The quality control department in such cases acts independently of receiving inspection.

The second input to this lo-level reliability program is secured from other factory areas. It comes from sub-assembly stations, through major assembly, final assembly areas, and flight-line operations; it is channeled back to the receiving inspection functional-test area.

This input is carried on a FEWT (Functional Equipment Withhold Tag) which is attached to a component suspected of malfunction as installed in the airplane system. A FEWT part is removed from the airplane and returned to the functional test area; where it is subjected to the same test given to a new, incoming part from the vendor.

The large volume of FEWT parts returned to functional test can be appreciated by understanding the philosophy of the assembly-line technician charged with testing the operation of a system within the airplane. His philosophy is that it is quicker to remove a component that is suspected of malfunction and to replace it with a new part, than it is to trouble-shoot an entire system. This results in some functionally-acceptable parts being returned to receiving inspection as FEWT parts. Actually, the average has run rather consistently at 50 per cent of the FEWT parts being acceptable upon retest.

As an aid to functional-test inspectors, shop departments, and engineering, the statistical section of quality control publishes a monthly FEWT summary. This summary gives a cumulative total of FEWT activity for a three-month period. The first output is the direct action taken from the data presented by the historical-record card and the inspector's rejection material review form. Action on this data is taken by both receiving inspection and statistical quality control groups.

Receiving-inspection personnel are quick to recognize one of the two following conditions: either a consistent record of high-rates-of-rejection of a particular part from a particular vendor; or a total-lot-quantity rejection of a vendor's part.

In either case, receiving inspection calls in engineering, to verify that the rejection is for an out-of-tolerance condition. Functional-test instruction specifies operating conditions and limits; each part is tested to these limits which sometimes are tighter than the limits set by engineering, for maintaining system operating parameters.

If engineering decides it can shift the limits, the functional-test instruction is revised accordingly. If engineering re-affirms the limits previously set, then receiving inspection notifies purchasing of the rejections, and asks them to contact the vendor for corrective action.

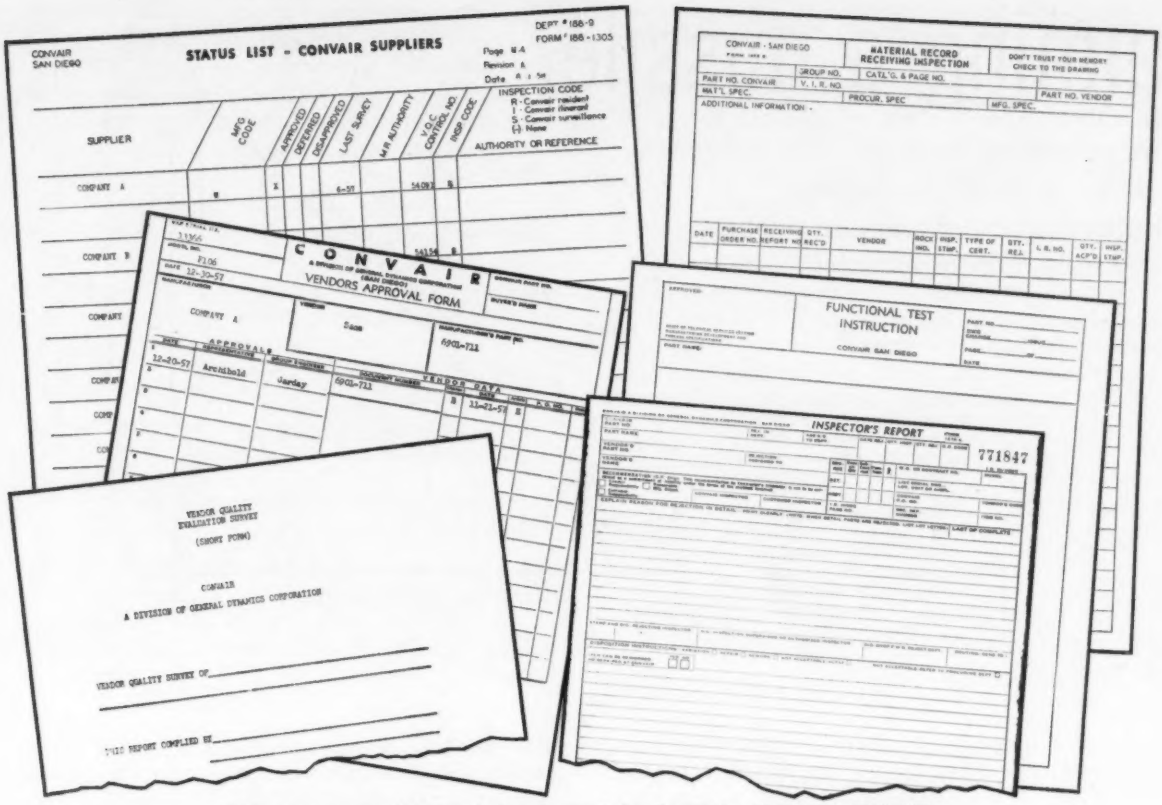
Often the vendor sends a representative to Convair's receiving inspection to help resolve the problem.

Generally, causes of total-lot rejections are easier to find than intermittent types. Such things as improper heat-treat on springs, insufficient testing by vendor, or omitted assembly operations are the cause.

The statistical quality control group also contributes to the first output. It makes a two-fold contribution.

First, it maintains a running tabulation of inspectors' reports on incoming lots of functional parts by number. This gives quick notification of parts which are suffering frequent rejection. The group's action on this notice is to communicate the reason for rejection to the vendor's quality control department and ask for corrective action. Sometimes this is the first notice the vendor has of the difficulty.

The second contribution to this output by the statistical group is the putting of vendor quality rating to work. Each month a new, current rating-list is published. As an adjunct to the vendor quality-rating, vendors whose rating is dangerously low are requested to appear for a conference. The conference is set up with the purchasing department, engineering procurement, and quality control. The rating system is explained to the vendor, his low rating is reviewed and a request for corrective action is made. Usually this is sufficient to bring about the desired action. The most usual corrective action required is implementation of a more effective



The above are data-input forms used in Convair's "Lo-Level Reliability Improvement Program."

quality control system. It is noteworthy that usually very few vendors have ratings so low as to require such action.

The second output is from the FEWT activity. Presently, this is conducted mainly by the receiving inspection functional-test group.

Retest of functional components is performed by functional-test inspectors. These are instructed to inform their supervisors as soon as they recognize unusually frequent returns of any FEWT parts.

Considering the consistent retest average of 50 per cent good, 50 per cent bad parts, if a number of parts are returned for retest, and all are found to be acceptable, a problem exists somewhere. The same assumption is true if the parts all fail to pass retest.

Upon notification of unusual activity on a particular component, the functional-test area supervisor assigns the problem to an experienced inspector for investigation. The inspector analyzes the reason for removal in the light of the functional tests.

This type of investigation has proven to be extremely rewarding in its results. Many cases of incompatibility between system test and component functional-test are found. Some cases have revealed that the difficulties were not with parts returned as FEWTs, but with parts upstream or downstream from the FEWT. Some cases reveal design discrepancies in the part not apparent upon ordinary examination. Occasionally, cases are found which stem from engineering groups mis-matching system parts or installations.

The FEWT monthly summary is utilized by receiving inspection functional-test group and numerous other groups. The functional-test group uses the summary to pick up parts with high FEWT activity rates not recognized as problem children by the retesting inspectors.

Assembly-line areas use the report to conduct their own investigations into an excessive number of parts removed in their areas.

Engineering reliability groups use the FEWT summary as a source of additional information, in their activities, relative to parts failures in the field.

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The Editor
AIRCRAFT and MISSILES MANUFACTURING
Chestnut & 56th Sts., Philadelphia 39, Pa.

aiming a missile

theodolite system aligns azimuth on Jupiter; entire flight depends on accuracy of pre-launch orientation

by G. Wallace, Electro-Optical Div., Perkin Elmer Corp.

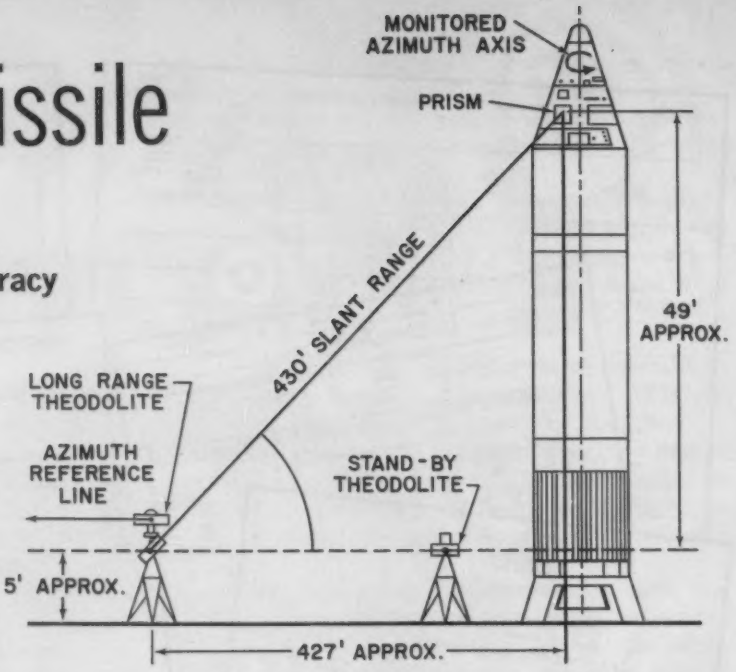


Fig. 1. Physical arrangement of azimuth aligning system in Jupiter is shown in this schematic. Furtherest theodolite focuses on mirror attached to Ford Instrument Co. gyro stabilized platform. Smaller theodolite is standby system in case line-of-sight in main theodolite is disturbed.

The most precise inertial navigation system, with the finest gyros our manufacturing technology is capable of producing, cannot deliver a ballistic payload even under the propulsive force of our most reliable rocket motor, if the guidance system is not precisely aligned prior to launch.

Inertial guidance is independent of information and controlling forces outside a missile; as such, it represents a near ultimate in self-contained navigation systems. Very basically, an inertial system consists of a computer, and a set of three orthoganally mounted "accelerometers" held angularly rigid in space by a gyroscopically stabilized reference platform.

The stabilized platform provides the only reference in space for the self-contained system and therefore requires critical angular alignment prior to launch. The entire delivery accuracy resolves itself into how precisely this reference platform is aligned to the target. In flight, the "accelerometers" sense the acceleration of the missile, and the computer doubly integrates these acceleration signals to give the position of the vehicle in comparison to previously programmed constants. When disturbances such as wind, or thrust misalignment cause a deviation from the programmed ballistic flight, the "accelerometers" sense the deviation and through the computer transmit steering signals to the appropriate thrust chambers.

Before cutoff, the computer integrates all variables to solve a cutoff equation, and translates inertial coordinates to Earth-fixed coordinates for delivering the payload. The proper solution of this equation is again dependent upon the proper alignment of the guidance platform prior to launch.

Azimuth Alignment

The direction, or track, of a missiles flight is determined by the azimuth alignment. In the case of the Jupiter IRBM this measurement is performed with a Perkin-Elmer Intermediate Range Alignment Theodilite. This precision optical-electronic-mechanical instrument package is capable of detecting azimuth misalignments and automatically making adjustments expressed in seconds of arc (one second of arc equals less than 1 millionth of a circle). The theodilite detects discrepancies in alignment by continuous observation of light reflections from a mirror mounted on the stabilized platform. The object is to orient the mirror "square" to the intended azimuth; in so doing, the longitudinal plane of the mirror is aligned through the local vertical, and the lateral plane is aligned perpendicular to the plane of the intended track.

Operating Principles

The monitoring optical system consists of:

- Two modulated light sources
- One telephoto objective lens
- One beam dividing "Vee" prism
- One photo multiplier tube.

When the system is energized, light from the two glow discharge lamp sources is directed at, and reflected from, the mirror or reflecting prism mounted on the stabilized platform of the guidance system. The two lamps are imaged at the focal plane of the telephoto objective by separate condenser systems, and a prism shaped mirror reflects the beams along the optical axis of the objective lens. The resultant signal produced by the photomultiplier is a function of the angular displacement of the monitored mirror from the autocollimated or "squared on" position.

If the monitored mirror is perfectly "squared on" the reflected light will re-enter the objective, fall on the opposite side of the prism and will be lost in the source system. Thus by being perpendicular to the line of sight, a null or no-signal condition results.

Tie-in to geographical reference is achieved by use of a high quality surveying theodolite incorporating an accurate azimuth circle and sighting telescope. The desired angle between the sighting or "reference" line of sight and the "monitoring" line of sight is set off using the azimuth circle. The "zero" setting of the circle is determined by autocollimating both systems from a common test mirror.

Deviation And Correction

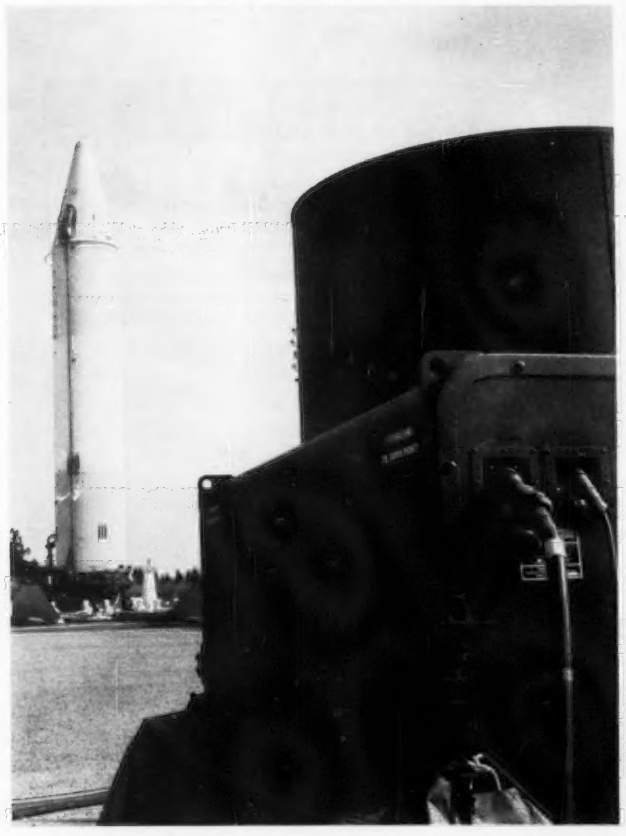
If the monitored mirror is rotated in azimuth even slightly, the returning beams will not be centered on the optical axis and, depending on the degree of rotation, will pass through a slit and strike the photomultiplier. In this manner an error signal output is produced which is representative of the direction and magnitude of azimuth deviation.

Error signals are fed to the stable platform to drive the platform back to conformity with the beam of light and thus correct the azimuth heading. The entire closed loop relationship, therefore, is automatically self-correcting. The platform is controlled automatically within very small limits and over relatively long periods of time.

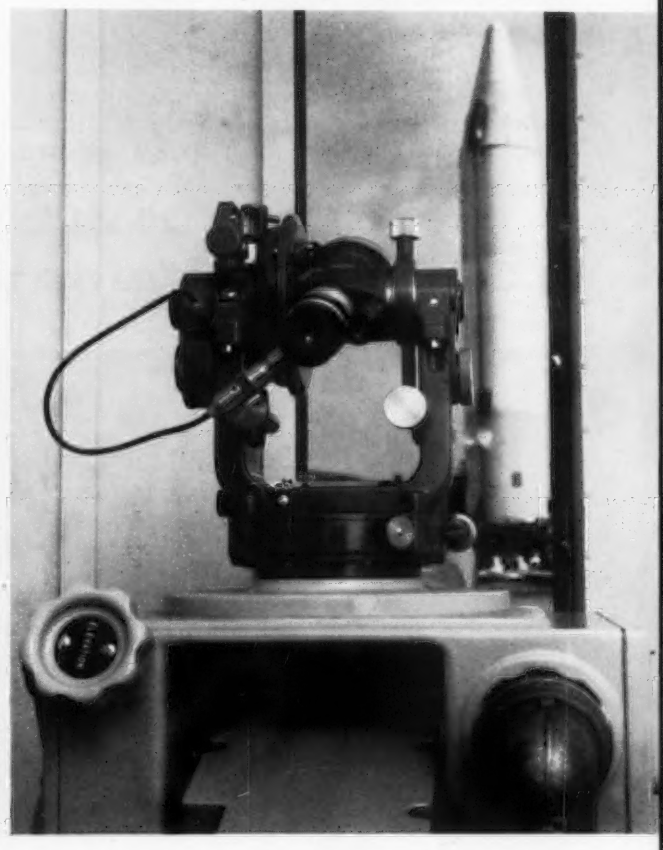
Jupiter Alignment

The Intermediate Range Theodolite for Jupiter is a variation from other alignment theodolite units produced by Perkin-Elmer. (See Fig. 1.) *continued on next page*

Main theodolite for Jupiter azimuth alignment is housed in metal shelter. Instrument is in a closed loop with the guidance system.



View from inside the shelter shows instrument focused on mirror in nose section. Mirror must be "squared" to intended azimuth track.



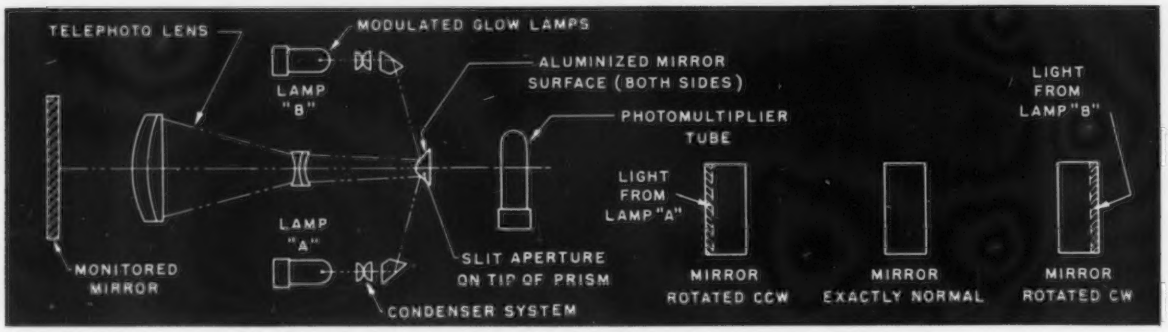


Fig. 2. Simplified schematic of optical monitor unit shows essential components. Inset rectangles show how various misalignments are viewed.

aiming a missile . . . continued

Aperture and focal length on the Jupiter theodolite are increased to 4 in. and 36 in. respectively because of the increased distances. Electronic unit consists of an amplifier, preamplifier, and a power supply-modulator.

Major sections of the theodolite are constructed of Meehanite castings for rigidity over the wide temperature ranges encountered. All exposed parts are of corrosion resistant stainless steel.

Primary And Secondary Targets

Two theodolites are used in the Jupiter system; a "primary aiming" model, which operates as described, and an "auxiliary" short-range model. The short range unit is stationed 3 to 4 ft from the base of the missile and sends beams to an auxiliary prism monitoring unit in the base of Jupiter. Auxiliary prism is tied into the reflecting prism on the guidance platform so that heading changes in one produce the same heading changes in the other. A second auxiliary monitoring prism is also attached to the launching ring but at a different azimuth angle. This second system is used for secondary targets, should a last minute change occur prior to launch.

Purpose of the short range theodolite, designed as an expendable item because of its proximity to missile blast, is to take over alignment in the event of poor weather or other atmospheric conditions which might distort the light beam in the long-range sighting.

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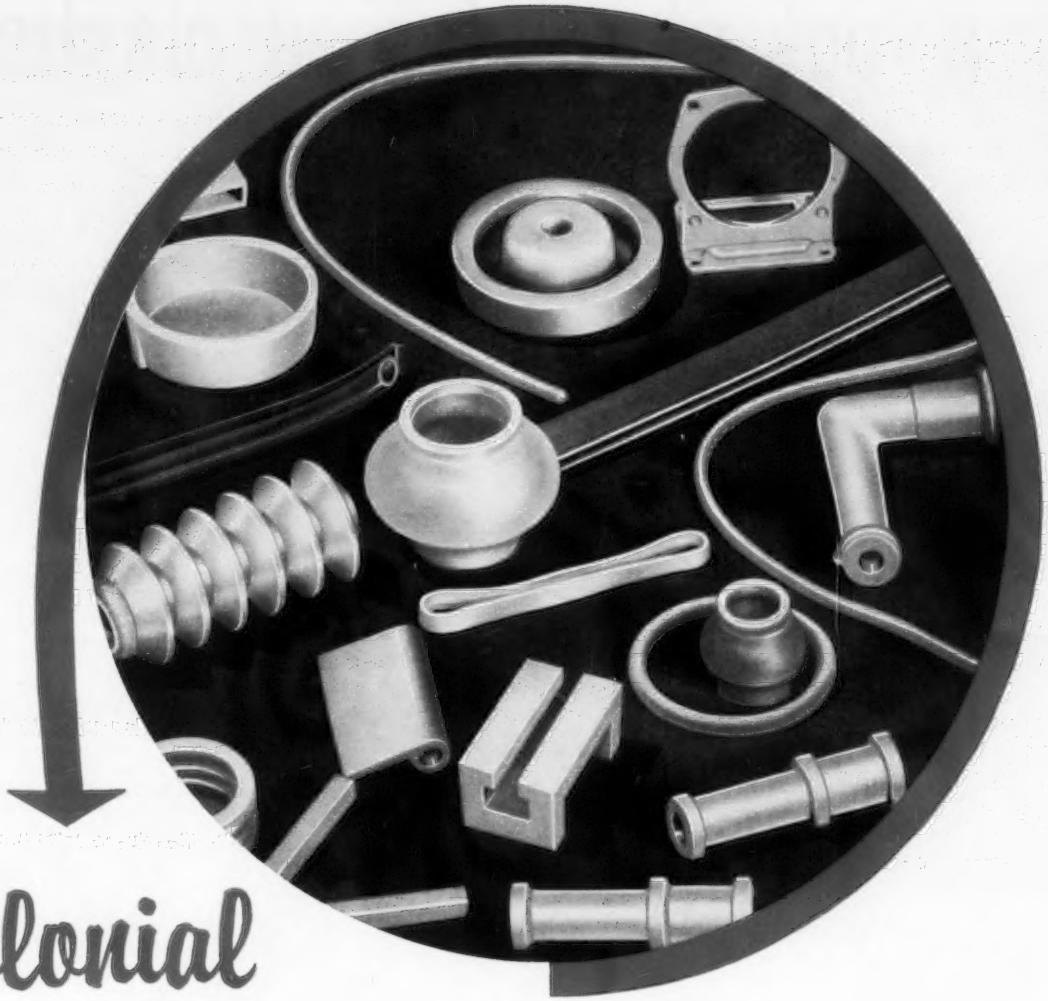
Auxiliary theodolite (left) monitors a mirror attached to launching stand. This mirror is tied into main mirror on guidance platform. System is a standby for foul weather.

Proximity of smaller theodolite to launch stand subjects it to intense heat of blast off. Instrument is designed as an expendable item.



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Circle 8 on Inquiry Card, page 83

a look at reinforced plastics

applications up, total poundage down; emphasis turns to new materials and processes; high-temperatures, high-pressures offer challenge

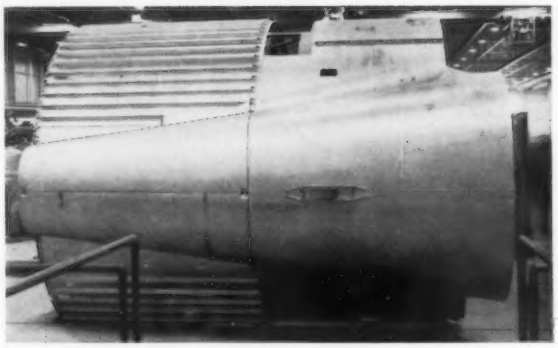
by John P. Kushnerick

External applications of reinforced plastic on Bell HU-1 turbine helicopter are shown in color. Radio compartment decks, fuel tank bulkhead, and work platforms are internal applications.

There is nothing new in the concept behind reinforced plastic construction. Even in ancient times, when homes were built of mud and twigs, the advantages of this type of construction were known.

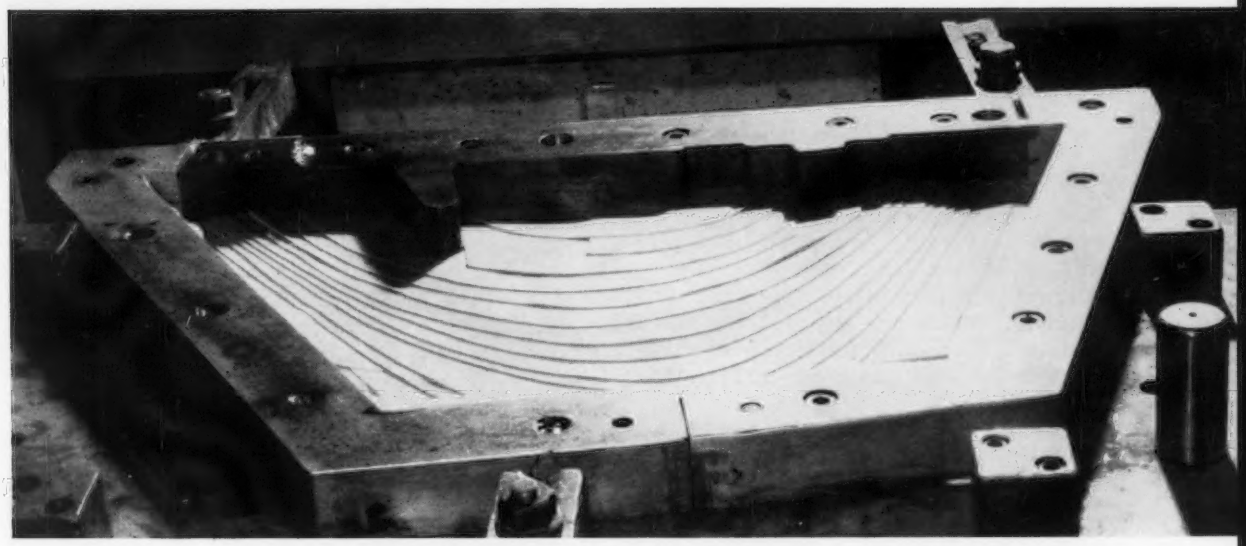
What is new is the refinement in materials of construction, and the expansion in applications. Historically, the more important developments in reinforced plastics have resulted from studies in the aircraft and missiles industry. High strength and high-temperature resins, printed circuitry, and high-pressure filament-wound vessels, are but a few of these developments.

During 1958, about 18½ million lb, or 10 per cent of the total reinforced plastic usage, went into the aircraft and missiles industry (Society of Plastics Industries). Ironically, the total pound usage in this industry has dropped while the variety of applications has increased. This can be attributed to the transitional state of aircraft and missiles, and the increased demands for less quantity and higher quality in final vehicles and related components.



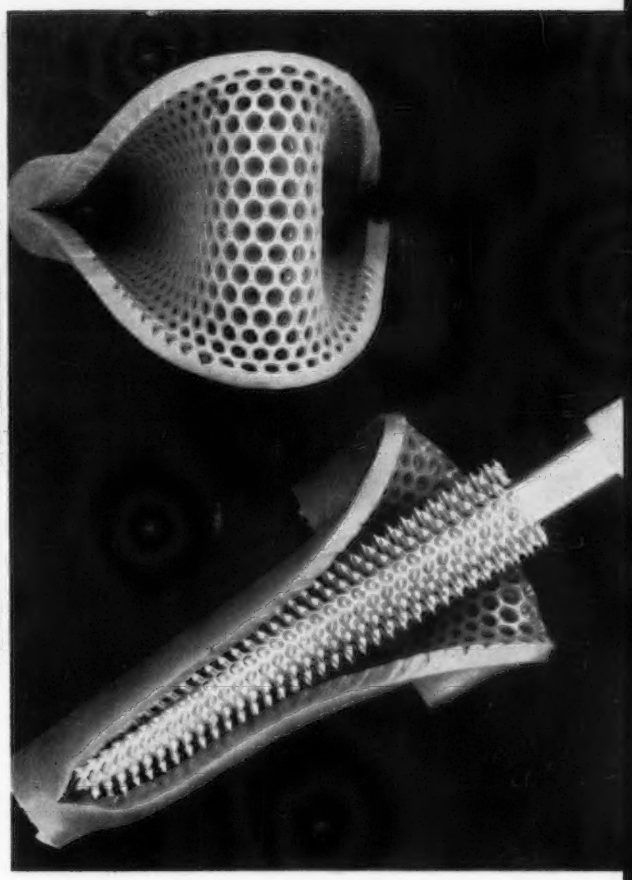
Thrust structure which houses rocket engines on Atlas ICBM is fabricated of Conolon 506 (181 glass cloth impregnated with resin, over metallic honeycomb)

Polyesters have been the dominant resin pound-wise, but the use of epoxies continues in an upward trend. Acrylics have made some advances, and recent work sponsored by Navy has produced some interesting urethane laminates. The Teflons have also been enhanced by reinforcement



Half of airfoil lay-up on Regulus II nose trimmers are shown in press-die, largest pieces are on top and bottom tapering to smaller pieces in center.

Airfoil trimmers are made of 50 different patterns of glass cloth. Thickest section of laminate is 150 plies; thinnest, six plies.



Master tool and plastic mold for igniter baskets in solid propellant rocket engines. Mold is used to form similar tools which are then filament wound to form final igniter basket.

in some instances; these applications, however, are in specialty items. ("homogeneous fiber polymer" AMM, Oct. '58.)

One material, fiber glass, has dominated as a reinforcing agent. However, asbestos enjoys considerable usage in high-temperature materials.

Specific Poundage

Boeing Airplane Co., has been a big user of reinforced materials as evidence by the fact that

2 per cent of the gross weight of Bomarc is of this type structure. This represents about 380 separate items, nearly 300 of which are epoxy. The KC-135 jet tanker has about 215 reinforced plastic items, representing 0.1 per cent of the gross weight. Phenolics, and epoxies are the major resins. The B-52 series has about 314 items, and the new 707 has nearly 720 reinforced plastic items.

Convair - Astronautics has recently announced that glass fabric is used to manufacture at least two of the major components of Atlas ICBM. These are, the structure used to house the two booster engines, and the instrument pod which houses on-board electrical equipment. The nose of the pod is fabricated of an phenolic honeycomb core with glass cloth reinforced skins. Remainder of pod is presently metal, however, engineering design changes call for constructing the entire pod of sandwich construction. Glass-cloth reinforced plastic skins are to be used over a phenolic, or metal core.

The Atlas booster housing is constructed of 181 glass cloth reinforced plastic skins over a metallic core, known commercially as Conolon 506. (Narmco Resins & Coatings)

Dead Birds?

Navy announced the cancellation of Regulus II late last year. Cancellation purportedly had little to do with the technical and strategic aspect of the "birds" mission. Whatever the reason, much design and production know-how came into being while the project was alive that will be of benefit in future missiles.

Regulus II is an aerodynamic missile, and is recovered on practice missions by incorporating a retracting landing gear in the fuselage and effecting an aircraft-type remote-control landing on mission completion.

To reduce landing speed (by reducing stalling speed) small movable airfoil sections were incorporated in the extreme forward section of the fuselage. The problem was to build these two-foot lift producers of a material that would not interfere with radio transmissions used to control the "bird" in flight. The material selected was glass cloth reinforced plastic. The method of fabrication was to use a 150 ton press and 320°F curing temperature. The result was to reduce landing speed by 26 kts.

The airfoils are composed of laminates, 150 at the thickest point, and only 6 at the thinnest point. Three sides of the airfoil have the 6-ply knife edge, these build up to a 1-in. thickness along the fuselage. Fifty different patterns are used to provide a smooth aerodynamic finish. Airfoils are recessed on the thicker root to accommodate steel forgings and magnesium clamps to interconnect the units through the fuselage and thus cause simultaneously up and down movement in flight.

The Layup and Cure

The 150 individual plies were cut from the glass cloth while the resin was wet. Excess solvent was dried out in "B-stage" precure.

The largest patterns were laid in the bottom half of the press die. The smaller parts were laid on in turn, and then larger pieces were used on the top of the layup. This produced a minimum of exposed edges. To prevent leading edge frilling in windstream, final three plies are cut oversized and lapped on the leading edge, tucked under at the trailing edge. Dies were pressed together lightly under 200°F. This allowed warming of the resin and escape of some of the gases between layers.

After ½ hr, temperature was raised to 320°F and full 150 tons applied for 2½ hr. Part is cooled under pressure, and post cured in an oven at 180°F for 4 hr, and 350°F for ½ hr.

Filament Winding

One of the newest techniques of reinforced plastic construction to be exploited in the aircraft and missiles industry is filament winding. Pressure vessels have been successfully fabricated this way for some years and have demonstrated lighter weight per unit volume capacity than corresponding metal vessels. The chief problem has been to attain even greater strengths known to be theoretically possible. (Almost twice presently attainable strengths.)

The strength properties of filament windings are believed dependent on four variables.

- Impregnation technique
- Surface condition filament
- Resins curing system
- Winding technique

It is further believed that the main load carrying capacity is derived from the filament (usually glass), and that these forces are distributed throughout the system by the resin. Continuity of filament, no breaks; and uniformity of resin, no voids, are therefore essential. Good adhesive bonds between resin and filament are also essential.

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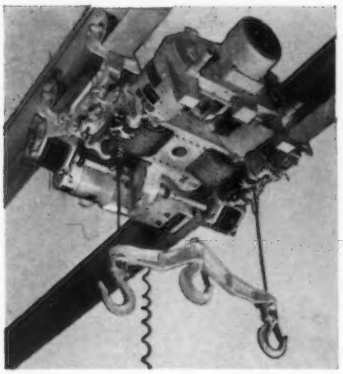
NEXT MONTH
Look for the Missile Handbook!

HIGH SPEED HANDLING

FLY-AWAY HOIST SPEEDS JET TRANSPORT



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The *PLASMARC* Torch employs a non-transferred electric arc to generate such high temperatures that powder or wire fed into the chamber is literally melted. Inert gases flowing continuously carry the metal particles in a plastic state and deposit them on the workpiece at near-sonic speeds. Jets of CO_2 cool the particles instantly to form heat- and erosion-resistant material. Coatings—even on graphite—have an excellent bond. Shapes are built up on machined mandrels, which are then etched away to leave parts such as those shown above.

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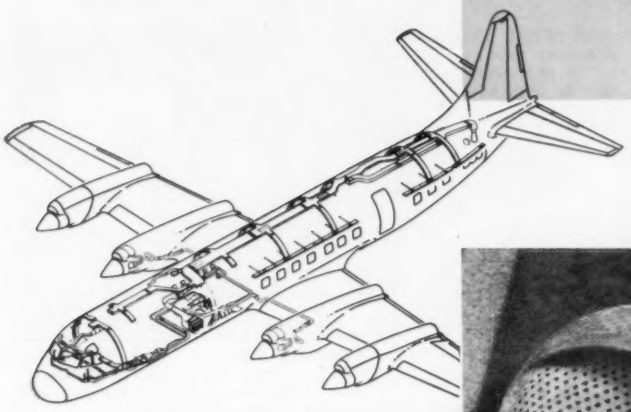
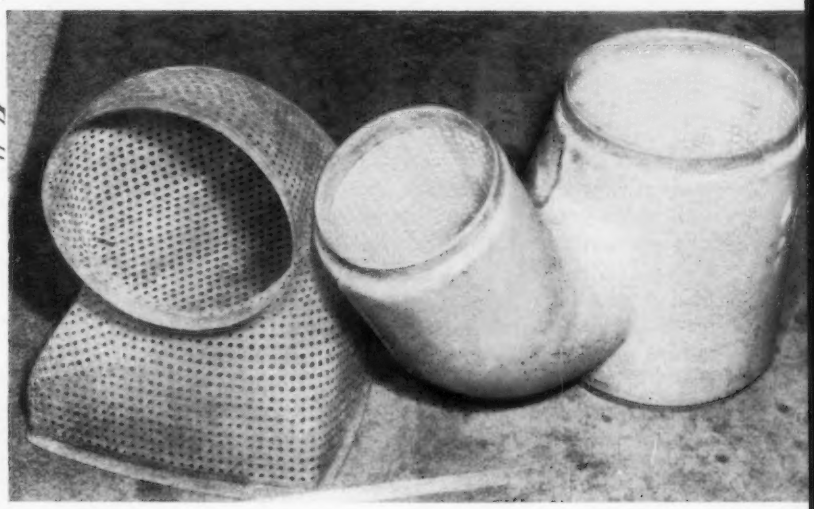
plastics in Electra

over 1000 applications in Lockheed turboprop many metallic structures replaced; changes have not been without problems

by Robert P. Routt and E. A. Green
Lockheed Aircraft Corp.



Air conditioning the Electra requires extensive low-pressure air distribution system. Glass cloth laminates are used to save weight at no increase in cost.



To reduce cabin noise, where high velocity air is carried in ducts, double duct with sandwiched insulation is used. Inner duct is prepreg.

Plastics have taken the place of metal in many applications on modern airplanes such as the Electra.

Parts are never made of plastic, however, merely to exploit a new material. Sound engineering reasons are necessary for replacing the traditional metallic structures.

These reasons may include one or more of the following:

- Weight reduction.
- Cost reduction.
- Increase in heat and acoustical insulation.
- Reduction in maintenance.
- Corrosion resistance.
- Appearance.

Practically all types of plastics are used in Electra from glass fiber reinforced polyester and rag reinforced melamine, to unreinforced vinyl, Nylon and Teflon. Glass cloth reinforced polyester laminates and mat reinforced polyester moldings are used most extensively.

In most cases, there have been some problems working with new materials in a new aircraft. Outlining problems and solutions may be of worth to materials and process engineers.

Pre-pregs in Ducts

Airconditioning the Electra requires an extensive low-pressure air-distribution system. The necessary ducting is inherently heavy when constructed of metal, because minimum gages are established by production. These thicknesses are usually well above the structural requirements.

continued on next page

◀ Circle 10 on Inquiry Card, page 83

USE OF TOOLING MATERIALS AT LOCKHEED

(for glass fiber laminates)

Tool Material	Tool Configuration	Type of Cure	Remarks
Wood: Maple, mahogany, etc.	Simple shapes; single mold; made by cutting, carving, etc.	Contact to vacuum pressure; room temperature to sunlight.	Low initial cost; suitable for some pilot runs; poor dimensional tolerance and poor stability.
Plaster: Calcium silicate	Any shape; single mold; made by casting or slushing	Contact to vacuum pressure; room temperature to 300° F.	For hollow breakaway molds; adaptable to highly complicated shapes; usually one-time use.
Plastic: Epoxy resin with glass fiber	Simple shapes; usually single mold; made by casting or layup with fiber reinforcement.	Contact to moderate press pressure; room temperature to 300° F.	Much used for moderate production; frangible or meltable plastics may be used like breakaways.
Metal: Steel, aluminum, low melt casting alloy.	Any shape; single or matched molds, solid or collapsible; combine with plastics for some applications; pre-form for mat laminates.	Contact to high press or autoclave pressure; room temperature to 800° F. or possibly higher; heating may be built into tool, steam or electrical.	For high production; accurate dimensioning; relatively high initial cost, low upkeep; good mold surface.

plastics in Electra . . . continued

Thus, glass cloth laminates help save large amounts of weight at no cost increase.

Even ducts of simple configuration have a few problems which need solving to make production efficient. Some ducts are made by wrapping the layup with plastic tape to apply laminating pressure. This allows excessive resin squeezed from corners to remain in the flat areas and causes the parts to be substantially heavier than planned. By using pre-impregnated cloth, with a controlled weight of resin added before layup, weight control is achieved. The low flow property of the pre-preg minimizes the thickness tolerance of the finished product. End cost is comparable because the impregnated material, although slightly more costly, is easier to work in the factory.

To reduce cabin noise, where ducts carry high velocity air, double ducts are used. The inner duct is made from pre-perforated pre-preg and subsequently bonded inside the outer duct with a light insulating material between the two duct sections.

Another type duct section which must support several filters is approximately 24 x 30 x 36 in. It was originally made in one continuous operation over a plaster breakaway. There was much difficulty in getting this part into production because of the size and weight of the plaster.

After the initial production lot, the possibility of making this duct either on a collapsible mandrel or in two halves was examined. Design and production flexibility of reinforced plastics showed that either of these methods could be utilized. The duct was split into two components at a saving of $73.00, or about 30 per cent per duct. The detail part could be even more economically produced on a single mandrel, however, tooling costs for small quantities are higher than the 2-piece duct design. A cheap method of producing collapsible mandrels could reduce total cost.

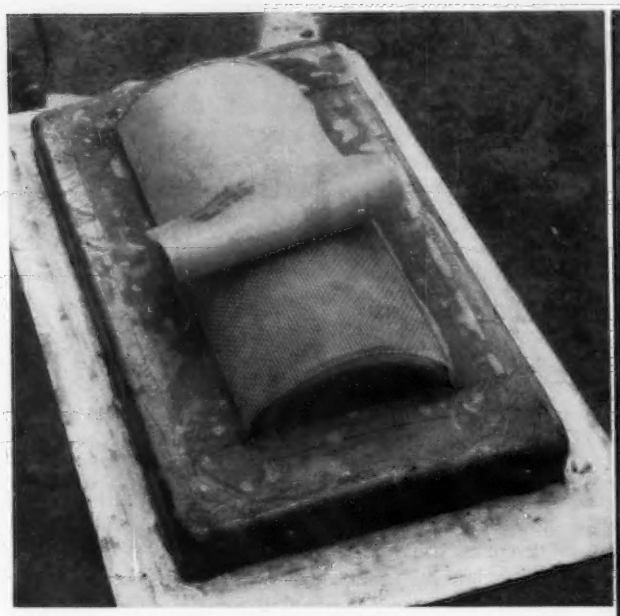
Thermoplastic Materials; Some Lessons

Thermo-formed ABS Copolymer sheets have been used for applications requiring attractive serviceable finishes. In some cases these are reinforced and stiffened with a back up layer of epoxy-glass cloth laminate. Original plan was to form the Royalite directly onto a pre-manufactured polyester laminate and to attach it by cementing. However, it was found more practical to vacuum form the Royalite first and then to build up an epoxy-laminate on the back of the pre-formed Royalite parts. The formed plastic sheet acts as the layup tool for the laminate.

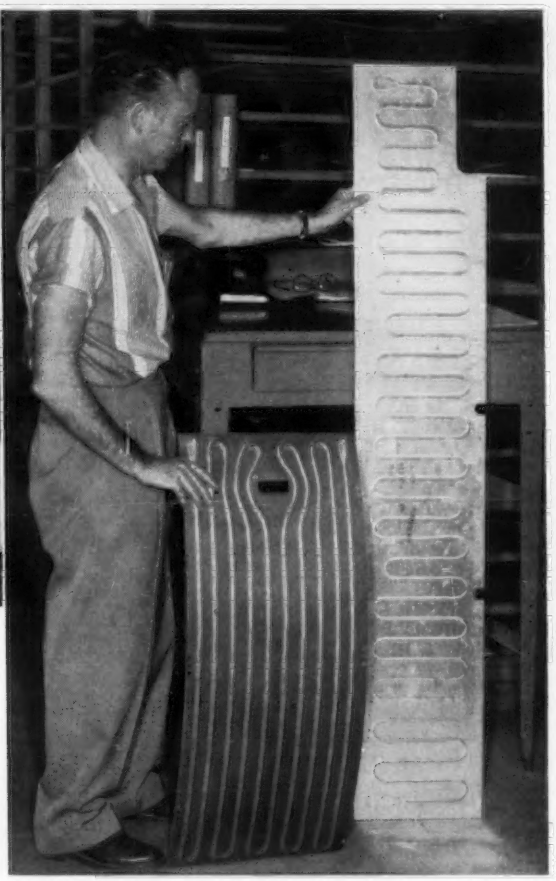
Primary concern with unreinforced, formed, thermoplastic materials is their tendency to distort with subsequent heating. Lockheed was hesitant to use the decorative materials of this type because earlier experience on the Constellation indicated that distortion could be a problem in localities where high atmospheric temperatures are encountered. However, the Constellation installation was considered a poor one because the 16 x 18 in. window reveals were supported in only two places. Learning from this experience Lockheed eliminated the possibility of service trouble by either reinforcing the material, or by properly restraining the parts on installation with an adequate number of attachments.

Nylon in Place of Vinyl

Rigid vinyl tubing is being used extensively throughout the cabin for electrical conduit to feed wires to heated wall panels and passenger services. A total of 890 linear ft of square con-



Combination metal-screen epoxy glass-fabric construction used to make retainer for insulation batting is vacuum bag molded. Silicone pad is laid on screen to keep resin from completely filling screen holes.



Electric radiant heating panels on Electra have heating elements rolled into honeycomb slab. Cavities are filled with epoxy resin. Aluminum alloy (0.005 in.) and epoxy glass-fabric are used for final cover.

duit is used, and 450 ft of round conduit. A family of elbows and tees are used in conjunction with this conduit, as pull boxes, and to lead the wires into the required areas. Lockheed had five ship sets installed, when an early airplane was painted and dried under the infra-red lights. In one ship a supplier substituted an "equivalent" vinyl in some fittings. The paint-baking temperature caused extreme distortion of the parts made from the substitute material. The fittings were not useable and were replaced. There are 256 of these fittings per ship. To avoid possible repetition and save weight Lockheed subsequently changed them to Nylon.

Theromsetting Plastics

Melamine reinforced with macerated cotton fabric was specified for decorative escutcheons. These parts were originally made from cellulose fiber filled melamine because of its smooth finish. It was found that this material, in thicknesses which are desirable weightwise, gave parts which were too brittle even to get through stock room handling and onto the airplanes. A compromise now sees the use of rag filled material which will be satisfactory in service. Some of these parts will have as many as 20 stainless steel knurled studs molded integrally for installation and equipment attachment.

Cellulose reinforced phenolic parts have been used with considerable success, but here again difficulty arose because of the unauthorized substitution of a so called "equivalent" material by a Lockheed vendor. Apparently a change was made to gain ease of molding, requirements were overlooked. The parts made from substitute material have been cracking during installation.

Plex 55; A Weight Saving

Windows are made of biaxially stretched Plex 55. This revolutionary new material has enabled saving approximately 300 lb/plane. To save this weight, the Plexiglas is mounted rigidly, and makes the window assembly work as a diaphragm rather than as a bending member. Tests indicate that this material will have a substantially longer life than the materials presently being used.

To guarantee added safety, an inner and outer pane, each capable of carrying full pressure loads alone, are used. Tests also show that even a bullet shot through one of the windows while it is under pressure will not cause disintegration.

continued on next page

Needs Are Many

In the glass reinforced plastics Lockheed feels there is a need for:

- The ability to obtain finer finishes in both mat molded and low pressure laminates with and without integral color.
- The ability to obtain closer weight control.
- Materials with higher temperature resistance which are easy to work in the factory.
- Higher moduli, and strengths.
- Methods to reduce production costs.

In the ABS copolymer sheets there is a need for:

- Higher heat distortion temperature.
- Higher elastic modulus in bending.
- More permanent colors.
- Better color matching.
- Better formability and dimensional control.

Also needed is: more care in making substitutions by vendors so that equivalent materials are truly equal; more vendor care in making commitments to size, shape, and production characteristics of specialized materials so primes can stay out of trouble.

Tooling Considerations—Radomes

Having examined some typical reinforced plastic parts, the varied tools required for their construction should be considered. The nose radome is made in a single female mold cavity, so that the mold surface forms the airfoil finish. Tools are constructed of epoxy resin and glass cloth, reinforced with a steel framework. Pressure is applied by drawing a vacuum. Cure is accomplished in a heat oven at 250°F.

Tool Materials

Practically any material could be considered a tooling material for plastics, even liquids and gases. The commonly used materials on Electra, however, are wood, plaster, plastic, and metal (see table). Wood and plaster have been used for trial parts as well as production parts. A plaster "splash" can be taken from a wood model, yielding a female mold cavity. If a male mold is desired, the female plaster is covered with appropriate thickness of wax (allowing for part thickness) and then slushed with plaster.

For production parts, hollow plaster tools or frangible plastic may be cast from a master mold, one plaster tool for each part in a run. This procedure requires that the plaster subsequently be broken and away from the cured part. Beside subjecting the part to uncertain and undesirable amount of impact, the break-away system results in a lot of scrap plaster. A meltable or soluble material has been considered as an alternative but both are considered too touchy where heat and pressure cures are involved.

Plastic Tooling

Plastic tooling is used considerably because the costs are favorable when compared to metal tooling. Although more expensive per pound, plastic is generally less dense, easier to cast, form, and machine to shape. Since material cost is actually the smallest expense in total tooling costs, the workability of plastics results in a less expensive tool. But, plastics have drawbacks. Plastic is a good thermal insulator, often requiring longer to reach curing temperature. Plastic tends to wear, flow, and deform more than metals. This limits useful life of plastic tools. Metal tools are used on long runs, or where curing temperatures are critical. Combination tools sometimes retain the advantage of each material.

Materials and Process Considerations

The relationship between tooling for glass fiber laminates and the laminating materials is interdependent. The tool does not merely dictate the shape of the part, it provides the conditions under which a laminate can be manufactured. The tool engineer that recognizes this and makes adequate provision thereof in tooling design is contributing to a better glass laminate.

The glass fabric represents an important variable in part quality. Procurement specs at Lockheed, and elsewhere, allow cloth weight to vary plus or minus 11 per cent from the nominal. Lockheed is now evaluating the possibility of going to a 2 per cent tolerance.

The resins in use require a broad range of curing temperatures and pressures. Each resin and glass combination, as well as part configuration, requires special tooling considerations. No one material, method, or tool is best for all applications.

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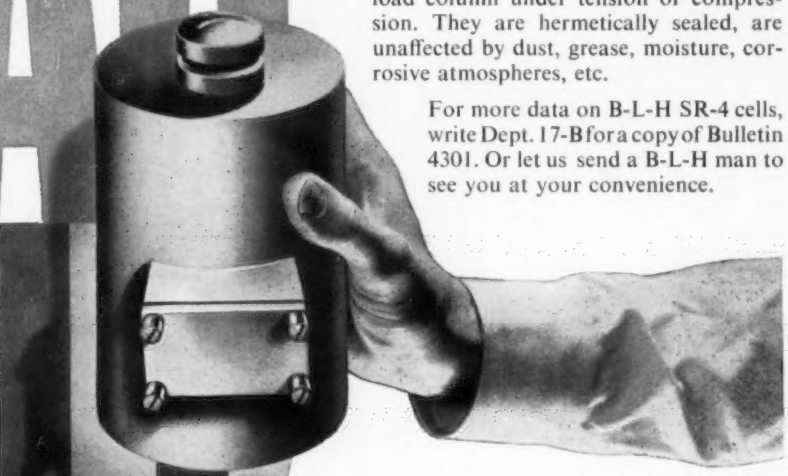

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Circle 11 on Inquiry Card, page 83

polyurethane foam

cast, or foamed-in-place, provides easy-to-produce structures, padding, and insulation.

by T. Patrick Dougan,
executive vice-president
and general manager,
American Latex Products

Spacers for pressure testing of DC-8 hull are made of polyurethane. (See text). Technician here prepares jointed aluminum surface with special parting agent.

Simplicity of process is demonstrated in how foam is placed in bolted mold. Foaming commences immediately after addition.

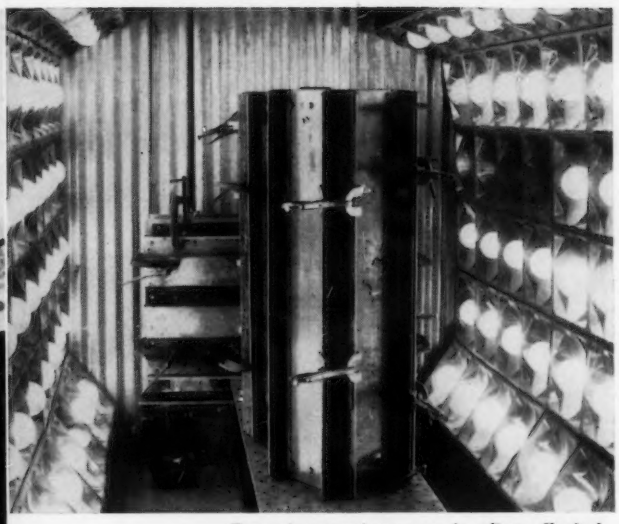
In the aircraft and missiles industry's headlong technological race, it is unfortunate that progress seems to increase only by the square of design complexity. It is refreshing, therefore, and encouraging, to note the development of any material that both simplifies design and production without decreasing efficiency. Polyurethane seems to be such a material.

Materials and process engineers have made tremendous strides in the development of this useful foamed plastic since its introduction in 1948. Virtually every airframe now contains some polyurethane in one of its many forms.

It is currently being used to strengthen airframes, change missile contours, line crash helmets, package delicate instruments, insulate aircraft and missile skins, pot electronic components, fill blowholes in metal castings, support fuel tanks, earphone pads, wind tunnel airfoils, liners for crews' clothing, commercial air transport seating, electrical insulation, testing devices, and radomes.

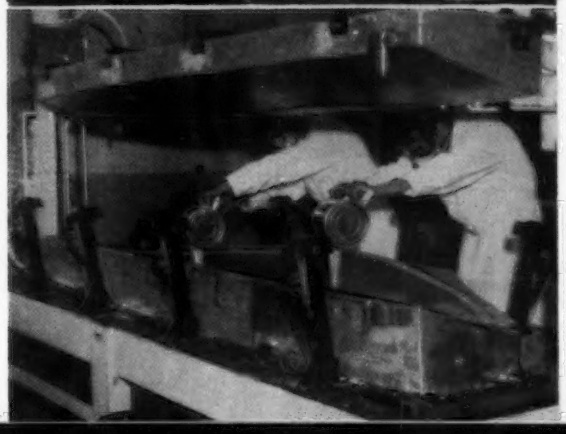
Molecular Construction Flexible

Such versatility is accounted for by the fact that formulas can be compounded to produce almost limitless variation of end-product physical characteristics from two basic states, flexible or rigid. Both forms can range in density from 1.5 to 70 lb/cu ft, with cell structures from absolute zero to better than 1½ in. diam. Either form may be colored with commercially available dyes



Room-temperature cure is often effected. However, short-time cure is used by Douglas. Infrared lamps provide heat in walk-in oven.

Fuselage fairings for KC-135 tanker are fabricated in this mold by sub-contractor Northrop Aircraft.



or filled with inert material or metallic powders.

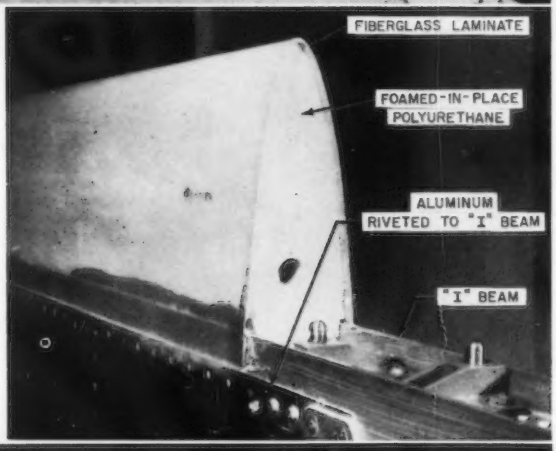
In addition, the material can be produced in any one of several "families" of compounds, chemically similar but with different molecular chains, such as the polyesters and polyethers. In each of these a particular parameter can be emphasized.

As an example, the hysteresis of the flexible forms of polyether and polyester makes the former better for seat cushioning, and the latter for crash padding. The reaction to force of polyether is roughly analogous to a spring and that of polyester to water. If a specified force is applied to the polyether, an equal reciprocal force is produced in the material at a linear rate, provided force and mass are equivalent. On the

Mold is made of 356 cast aluminum, is 10 ft long, 3 ft wide. After pre-heat to 120° F by six Calrods, rigid 5 lb/cu in. foam is hand poured. One-eighth in. vent holes provide escape passage for gas pressures.

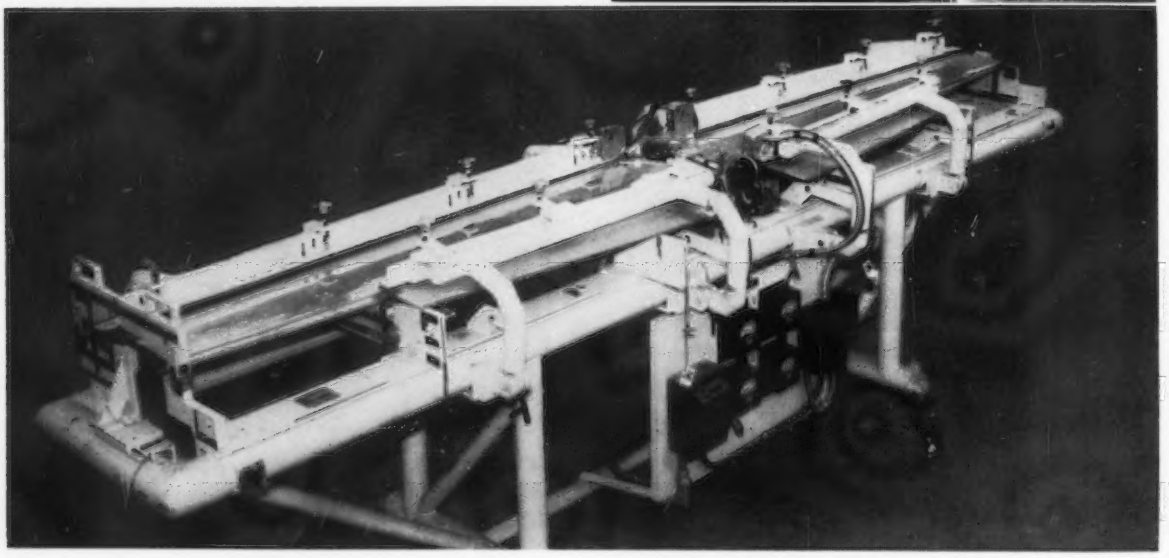
Radioplane RP-77 target drone nestles in cradle after coming off production line. Wing assembly is largely fiberglass and polyurethane foam.

polyurethane foam . . . continued



Close-up shows how foam and fiberglass are joined to "I" beam spar. Adhesive is used to effect fiberglass to spar attachment.

RP-77 wing is shown clamped in assembly fixture. Pressures up to 30 psi are generated during foaming. Ailerons and pod receptacles are not shown.



other hand, force applied to polyester is contained, meeting more simple resistance than reciprocal force. By varying the formula of polyester, reciprocal force can be reduced to the point where the material will return to its original shape only after a delay of from a fraction of a second to several minutes. Thus, the hazard common to both polyether and foam rubber, namely whiplash which can snap the neck of a pilot or passengers in a crash, is eliminated.

Cures At RT Or Accelerated

Curing polyurethane foam may be accomplished either at room temperature or by the application of heat. Heat-cured polyurethane exhibits superior qualities in nearly all cases, the heat producing better molecular cross-linkage and a more fibrous type of structure. Polyurethane, which is to be subjected to high temperatures, must be cured at temperatures exceeding the maximum expected.

Polyurethane components may be prepared in many ways. Some may be foamed-in-place, sprayed on with special equipment or cast in molds treated with a parting agent, others can be joined to other urethanes or to any non-waxy or non-oily surface with conventional adhesives and shaped fabricated with hand or power wood-working tools. Rigid polyurethanes may be molded or machined on conventional machines to tolerances of 0.002 in.

In foamed-in-place applications, the polyurethane is poured into the cavity immediately after mixing where it commences to foam, filling all voids and bonding to the skin material. If the material is to be molded and then bonded in a separate operation, the cavity walls are treated with a parting agent.

Self Extinguishing

Rigid forms have low moisture permeability, high compressive and shear strength, and strength to weight ratios under extremes of temperatures and distortion pressures. Flexible foams have high resistance to abrasion, aging, and tearing. Certain formulations of polyesters are flame retardant and self extinguishing.

Solid rigid polyurethane have the unique property of being virtually impervious to any known solvent, and, in addition, have tensile and compressive strengths ranging from 18,000 to 46,000 psi.

Industry today consumes millions of pounds of all polyurethane forms annually. About two-thirds of this amount are currently being used in production and about one-third for experimental applications. In many instances, polyurethanes are replacing honeycomb, and other materials.

One single company, American Latex Products Corp., alone supplies basic polyurethane formulations or fabricated parts for more than 1,000 separate uses in the aircraft, missiles, and atomic development fields.

Applications—Variable

Flexible polyurethane foams are used mostly in non-technical applications, such as airline seating. For several years, Temco Inc., Hardman Tool & Eng., Hiller, and others have been producing seat cushions and backs for the Lockheed Constellation and other planes. The principal advantage is the fact that such seats weigh almost exactly half that of the foam rubber formerly used. In addition, the material is not affected by food spilled during rough weather, or by body acids.

Hughes Aircraft, Beckman Instruments, and others use polyurethane not only because of its excellent protection against shock, but because the material itself is inert and will not tarnish or otherwise chemically affect highly polished precision parts. In one application, thin sheets of polyurethane are used as replaceable coverings for the floor of a dust proof instrument assembly room since polyurethane also has the ability to hold dust.

Microscopic-celled polyurethanes, known as Poly-rubber, have found widespread use as fuel cell and pump seals and diaphragms, and as gaskets. All jet passenger aircraft now on drawing boards or in production will be equipped with emergency passenger oxygen masks made of this material because it is rugged, extremely light in weight; and most important, it is not embrittled by oxygen.

Rigid polyurethane foam are used mainly for technical applications. Their ease of production and fabrication and high strength to weight ratios make them ideal for simplified mass production.

The Radioplane Drone

For example, the RP77 target and other drones manufactured by Radioplane Co. of Van Nuys, Calif., are fabricated largely of fiberglass skins filled with foamed-in-place polyurethane. The only metal structural member is the aluminum wing beam. Where very high strength is needed, as in the leading edges of the wings, a 40 to 60-lb density polyurethane foam is used. Less critical trailing edges are foamed with materials as low as two-pounds in density. This type of drone takes more punishment from near misses than conventionally constructed targets. In addition, it floats on water regardless of damage inflicted.

continued on next page

polyurethane foam . . . continued

On the main wing of the target drone fiberglass laminations form the leading edge; trailing edge, ailerons, and pod receptacles with polyurethane foamed in place. The aluminum skin of the center section is riveted to "I" beam spars so the skin edge is about one inch from the edges of the spars. The leading and trailing edge sections are fabricated so the channels, equal in thickness to the "I" beam material and one inch deep, are located between the polyurethane and the fiberglass at the base of the part. The inside of the channel and the outside of the exposed section of the "I" beam are spray-coated with adhesive. The parts are fitted together, placed in a jig, clamped, allowed to set, removed, cleaned of excess adhesive, ailerons and pod receptacles fitted in place, painted, and the wing is ready for final assembly.

In fabricating the vertical stabilizer, the pre-formed fiberglass skin is inserted in a specially designed mold, the top is bolted in place, and the stabilizer foamed-in-place with polyurethane (Stafoam). Adhesion between the foam and fiberglass skin is greater than the cohesion of the foam itself. During the foaming process pressures as high as 30 psi are generated so the mold is made rigid with ½ x 2 in. steel braces. Parts are held to ±0.005 in. tolerances on production runs.

In a similar operation, Douglas and other manufacturers are foaming the interiors of all empennage, doors, hatches, and similar assemblies. Polyurethane is effectively used in these applications for eliminating skin cracking between rivets by damping sonic harmonic vibration. It is also utilized by Douglas fuel cell supports.

Electrical And Thermal

Polyurethane's excellent dielectric constant, power factor, and loss-tangent fit it for use as high quality electronic insulation, as the filler for fiberglass-sandwich-constructed radomes, antennae and loops such as those produced by Lockheed. Many aircraft and missile electronic components are now potted with polyurethane since it provides rigid support at high G rates, does not melt, protects components from vibration, and insulates them from heat.

It is receiving widespread use by Douglas, Boeing, Convair, North American, and other airframe and missile manufacturers as thermal and sound insulation. Convair is using three different types of polyurethane to completely insulate the cabin of the 880 jet airliner from temperature extremes. Douglas is covering most hot air ducts for both vibration and thermal insulation. K factor Btu 2/°F. is 0.21 in one formulation.

Packaging And Testing

Rocketdyne uses it for experimental contouring of shells and nose cones. General Electric Co. packages and protects highly polished precision characteristics of Atlas heat-sink nose cones in containers molded of polyurethane. Operational rockets and missiles at the U. S. Naval Ordnance Test Station at Inyo Kern are guided by fins which, except for an attach plate at the base, are completely foamed in one piece without the use of metal or fiberglass skins.

Boeing has in operation a wind tunnel with blades fabricated of polyurethane-filled fiberglass for improved operation at lower cost, less maintenance.

Northrop and Douglas cold anneal parts in liquid nitrogen contained in a tank insulated by foamed-in-place polyurethane. This tank has proved the solution to liquid nitrogen loss as the K factor of polyurethane decreases as temperature is lowered.

A unique use of rigid polyurethane is being made by Douglas for pressurized cabin tests. Originally, hull sections were sealed off, covered with a soap film, and then pressurized. Pinholes or imperfections were revealed by bubbles. Occasionally, the large volume of air escaping through a flaw would fatigue the metal, and cause the section to explode. To minimize the danger, sections were immersed in water-filled test tanks, necessitating removal from production lines and consequent cleaning. The problem was solved by filling sections with easily handled, contoured blocks of lightweight polyurethane. This reduced air volume to nil without a sacrifice in pressure.

The relatively new, solid polyurethanes are likely to prove even more useful than the more familiar foams. These compounds have an almost limitless potential of application. (Polyurethane Elastomer, AMM, Dec. 58.)

Because of the only recent availability of solid polyurethane, it is being used for but a few production airborne applications. On the other hand, its extreme versatility is stimulating research in more than a score of fields.

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Circle 12 on Inquiry Card, page 83 ▶

Chances of recovery in "Kingfisher" are greatly enhanced by complete sealing of fuselage with RTV silicone rubber. Cost of material and application is less than with previous organic sealant.

silicone elastomer

cures at room temperature; introduced as high-temp sealant, finds encapsulating and tooling uses

by **Robert Treat, Jr.**, rubber specialist, Silicones Div., General Electric Co.

RTV (room-temperature vulcanizing) silicone rubber was developed to meet the need for a high-temperature aircraft and missile sealant. Only one year after its commercial introduction this material has been used in production vehicles by several aircraft and missile manufacturers.

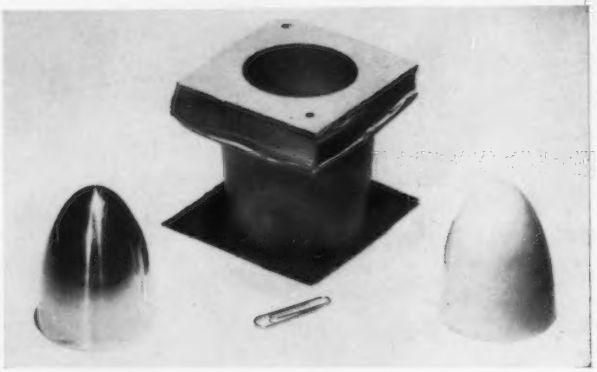
The first development targets for RTV silicone rubber were based on Douglas Aircraft's high-temperature sealant specifications for the DC-8. To meet these specifications a sealant had to offer:

- Room-temperature curing.
- Solids content—95 per cent min, 100 per cent preferred.
- Specific gravity—2.0 max, 1.5 preferred max.
- Viscosity—10,000 poises.
- Work time—2 to 4 hr, longer preferred.
- Cure time—24 hr tack free, shorter preferred.
- Shelf life—six months.
- Durometer—50 ± 15, fully cured.
- Bonds to aluminum and stainless steel.
- Heat resistance (retain some flexibility no cracking, no blistering, maintain adhesion)—500 hr/400°F, 168 hr/500°F, 40 hr/600°F.

RTV silicone-rubber compounds now meet or exceed these specifications and have been accepted as the only approved high-temperature sealant in certain areas of the DC-8. They are used extensively on this new jetliner for sealing wing leading-edge interiors, hot-air ducting, and around the radome. Satisfaction with RTV compounds has led Douglas to use them on four other projects.

Douglas Developes Techniques

Many of the manufacturing techniques were actually developed by Douglas. The material is applied by pressure guns similar to those used with other sealants. A variety of interchangeable plastic nozzles are used to make it easy for the operator to apply a bead of the right



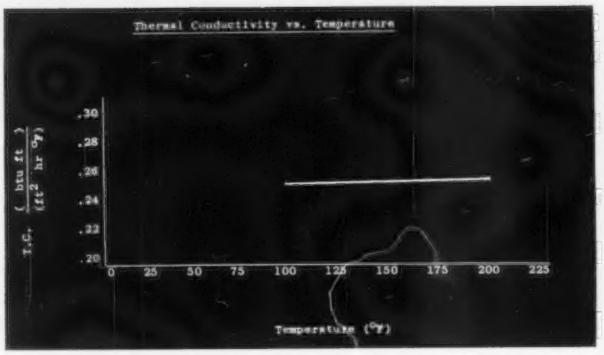
One of 12 epoxy plastic model jet engine nose cones (right) cast in one mold made from RTV-20 (center). The glossy surface of the plastic cone indicates the ability of RTV material to duplicate polished finish.

size and shape for each application. Since it is important that catalyst be added in the correct quantity and thoroughly mixed with the RTV compound, a specially-designed machine meters and mixes the catalyst. The catalyzed compound is then placed in plastic cartridges which fit the pressure guns. These cartridges are stored in refrigerated lockers and withdrawn by operators as needed. Low-temperature storage retards the action of the catalyst until the material is actually used in production. Mixing equipment and pressure guns were developed by Semco Research, Inc., Inglewood, Calif.

The Lockheed Missile Systems Div. is also using an RTV sealant in the "Kingfisher" recoverable target-missile. The Kingfisher was designed to be recovered after flight, but chances of recovery seemed poor in first tests because a sealant could not be found that would withstand the flight environments. Temperatures reach 300 to 700°F, internal hull pressures go as high as 25 psi.

Electronic Applications

Needs for a high-temperature sealant were paralleled by the need for a material to provide physical and electrical protection for airborne electronic equipment. Electronic components, to be dependable, must be protected from the rigors of extreme operating temperatures, fumes, moisture and harmful mechanical stresses such as vibration. This means that they should be cushioned, held and covered with an elastomeric or rubber like material. The ideal elastomer for this purpose should be applicable by pouring, spraying, or painting; it should provide vibration dampening; it should not shrink or deteriorate after exposure to high temperatures; it should remain flexible at extreme low temperatures and remain inert to ozone, oils and other chemicals over a wide temperature range. These requirements have been satisfied by new RTV compounds having properties similar to the sealing and caulking compounds, but generally lower in viscosity. An important property to consider in encapsulating electronic components is thermal



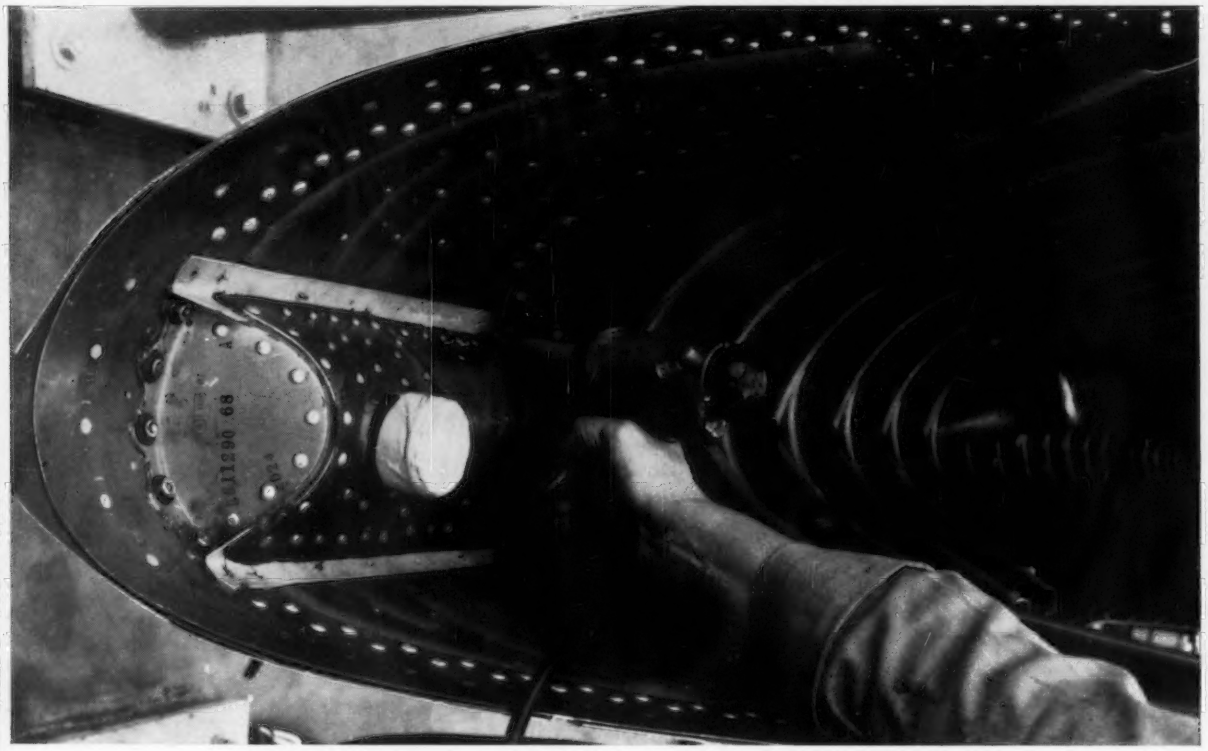
conductivity. This property is mainly dependent on the amount and type of filler in the polymer. The data in Figure 1 is typical for the encapsulating compound formulations.

Hughes Aircraft Co. was one of the early users of RTV silicone rubber for electronic potting and encapsulating. It has had excellent results encapsulating pulse and power transformers, reactors, magnetic amplifiers, and similar components. For potting applications, a reduced viscosity may be desired. This can be accomplished by the addition of General Electric SF-69 silicone fluid.

RTV As A Manufacturing Aid

The Production Engine Department of the General Electric Co. has found many applications for RTV silicone-rubber molds in the production of jet engine models. The elimination of parting agents with RTV enables the plastic model to duplicate fine surface-finish and detail which are lost in most other flexible mold techniques.

Wire inserting fixtures, used by the G-E Specialty Electronic Components Department in the manufacture of magnetic memory storage units, are extremely expensive to manufacture by conventional methods. Manufacture of these fixtures demands the highest degree of precision



RTV silicone rubber being applied as sealant for integral hot-air duct on leading edge of wing section on Douglas DC-8. Gun applicator, with variety of tips is used.

since the grooves for the wires are only 0.060 in. deep and 0.015 in. wide. In addition, small rectangular cavities at the junction of the wire crossing must accurately locate a miniature ferrite core. An accurate RTV silicone mold, made from an aluminum and brass master pattern, can normally supply as many cast epoxy tools as production may require. The fine detail, required was achieved by first coating the surface of the master pattern with RTV. An air blast was then directed on the pattern to force the liquid rubber into each groove and cavity. The result was an RTV mold that duplicated the original in every detail.

A recent situation involving Lear, Inc., illustrates the success of RTV as a "do-it-yourself" compound. The manufacturer's problem concerned the handling of gyroscopes. During assembly and test, an aluminum jig was used to hold the gyroscope unit in place. The unit was repeatedly inserted and removed from the jig in sequence of operations at various stations on the assembly line. Each time the unit was set into the jig, the load on the bearings was equivalent to several times the force of gravity. As a result, the overload on the bearings caused a continual source of trouble. The introduction of RTV solved this problem. A simple mold was roughed out of plastic and an RTV copy of the aluminum jig was then made and tested. The RTV rubber jig provided a soft cushion upon which to set the gyroscope unit, thereby relieving the problem of overloaded bearings. Since only a few dozen jigs were needed in this case, RTV was far less expensive than purchasing a mold for a standard rubber jig.

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RTV PROPERTIES—UNCURED AND CURED

Uncured	RTV-20	RTV-60	RTV-90
Color	Pink	Red	Red
Viscosity	30,000 cps.	70,000 cps.	1,200,000 cps.
Solids, %	100	100	100
Cured 144 hours @ room temperature with Silicure L-24			
Specific Gravity	1.30	1.45	1.45
Hardness, Shore A, Units	50	60	60
Tensile Strength, psi	450	650	750
Elongation, %	140	110	160
Tear Strength, lb/in., Die B	25	50	50
Linear Shrinkage, %	0.2	0.2	0.2

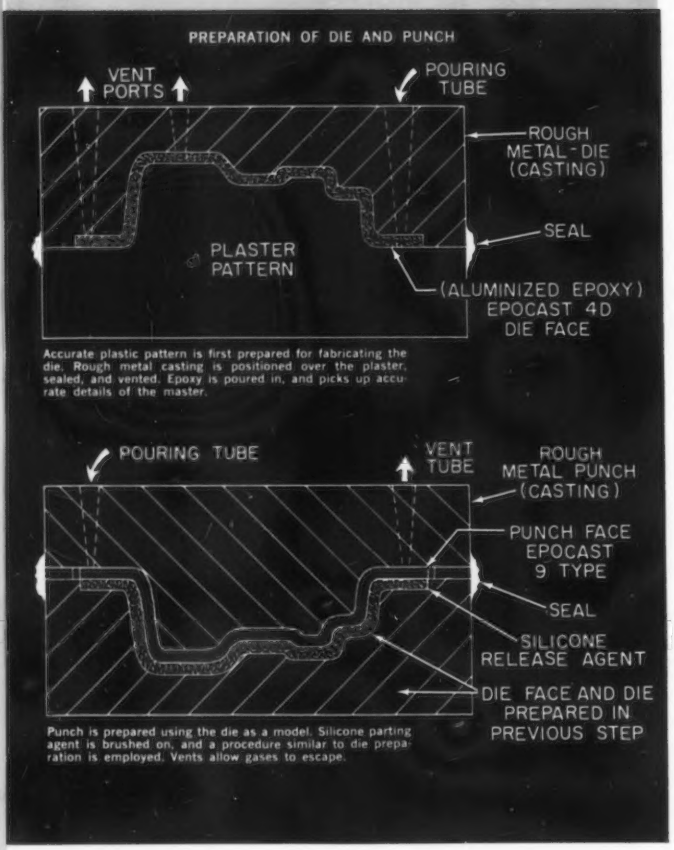
PROPERTIES OF RTV AFTER HEAT AGING

	RTV-20	RTV-60		RTV-90	
	24 hrs. 400°F	24 hrs. 400°F	40 hrs. 600°F	24 hrs. 400°F	40 hrs. 600°F
Hardness, Shore A, Units	50	65	75	55	65
Tensile Strength, psi	430	650	525	700	525
Elongation, %	140	110	70	150	100
Tear Strength, lb/in., Die B	25	35	40	50	35

drop-hammer tools from epoxies

rough castings faced with plastic used on die and punch for short/medium runs

by John Delmonte, general manager, Furane Plastics Inc.



Accurate plastic pattern is first prepared for fabricating the die. Rough metal casting is positioned over the plaster, sealed, and vented. Epoxy is poured in, and picks up accurate details of the master.

Punch is prepared using the die as a model. Silicone parting agent is brushed on, and a procedure similar to die preparation is employed. Vents allow gases to escape.

Plastics have been used for several years by aircraft manufacturers in the preparation of drop hammer dies for fabricating metal parts. The materials and processes used promise to augment the tooling and manufacturing procedures of missile manufacturers.

Typical drop hammer tools consist essentially of rough metal castings which are faced with a plastic cast in place.

The plastic, primarily an epoxy, accurately reproduces the dimensions and precise details of the mold against which it is cast. Hours of costly machining are avoided and costs of duplication are low when compared to the original model or pattern preparation.

Metal—strong, low cost, available, and reclaimable, makes up the body of the die, providing strength and reinforcement to the working plastic face. Metal dies are cast beforehand from steel, zinc alloy, or aluminum. Accurate tolerances are not required because these are picked up by the plastic face from the mold or pattern.

Die Preparation

The steps of preparing plastic faced metal dies are:

(1) Positioning rough metal casting with respect to the mold. Provisions are usually made to limit the thickness of the plastic face, about ½ in., though with special formulations several in. thickness is feasible.

(2) Location of pouring tubes and "bleeder" holes to provide escape channels for air entrapped during the pouring operations.

(3) Effective sealing of all openings and mold parting lines and planes from the leakage

Rohr Aircraft Corp. uses drop hammers with Epocast 7D face, with laminated epoxy backup, and Epocast 11 D core. Die and punch are occasionally removed from the press for hand cleaning and patching.

of liquid plastic as it is poured. Tape followed by plaster seals are common.

(4) Curing of the epoxy plastic at temperatures of 70 to 90°F for 24 hr.

(5) Opening the mold, and performing any cleaning, trimming, sealing or patching as required before the tooling is placed in operation.

Material Selection

For preparing the plastics die facing, a rigid epoxy plastic is used such as the material listed in Table I. An aluminum-colored epoxy plastic, it is tough and capable of long production runs. Typical of the formulations is Epocast 4D, which is hardened on the addition of 8 per cent HN-951. Some tool manufacturers employ 5 to 10 per cent flexibilizer (Flex "T") for additional toughness. (Ed. note: Specific aircraft and missiles manufacturers have for one reason or another concentrated on one or several resin brands. See Feb. 58, AMM "Plastic Tooling-Epoxies Move In," for resins in use at Avro.)

TABLE I

TYPICAL PROPERTIES OF DIE FACING EPOXY

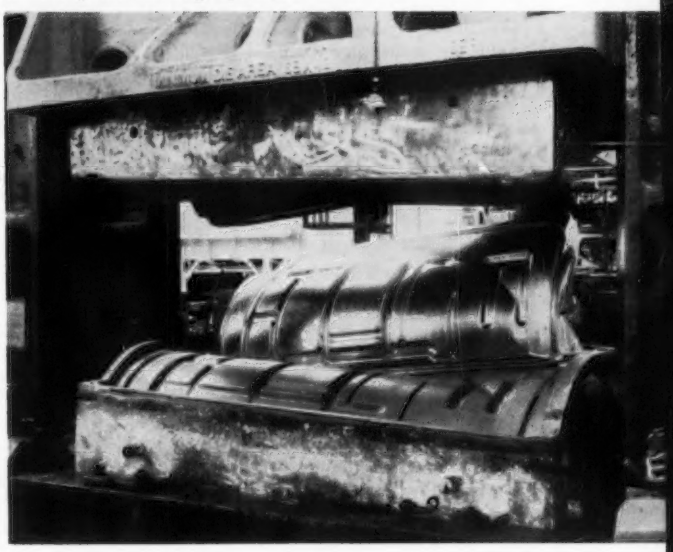
Specific gravity	1.50 g/cc
Shore D hardness	85 to 90
Tensile strength	7000 psi
Ultimate comp. strength	16,000 psi
Modulus of elasticity	600,000 psi
Linear expansion coefficient	3.3 X 10-5 in./in./F°
Adhesive bond to Kirksite	1200 psi
Effects of oil and grease	none

Punch Preparation

The punch half of the drop hammer tool is usually fabricated with a resilient epoxy facing. When broad radii are present and gradual changes in contours followed, the resilient facing may be cast against the rigid-epoxy die facing coated with release agent without clearing for metal thickness. However, for abrupt changes in dimensions, sharp radii, etc., it is desirable to use a high temperature pattern makers' wax to clear for metal thickness. Specific steps to follow include:

(1) Position rough metal casting above the mold as in Fig. 1. Thickness of punch facing should be limited to about ½ in. unless a formula

In use at Lockheed, drop hammer fabricated of materials described in schematic, is used in difficult pillow-forming operation.



is used which permits greater thickness. Contain the resilient material within the metal casting, and do not carry the material to the outside periphery of the tool. The mold is cleared for material thickness at deep draws and narrow ribs where the punch cannot be expected to yield for the metal thickness. The die facing, accurate in detail, will be picked up by the resilient punch facing. A silicone type release is brushed on the die facing.

(2) Locate bleeder and pour points as before.

(3) Seal along mold parting lines. Masking tape, followed by a plaster-hemp mixture is recommended for preventing leakage at mold parting lines.

(4) Cure at room temperature for at least 16 hr. Open tools, separating punch and die facings, and cure for another day at room temperatures of at least 70°F.

(5) When storing the tools, store in an assembled position, punch and die together. If stored outside in cold weather, allow tool to warm up to room temperature for 24 hr before placing in service. This is important, because most resilient epoxies become brittle at freezing temperatures.

Punch Material Selection

The epoxy plastic, selected as the punch facing material, is usually of a semi-rigid consistency such as Shore "D" hardness of 55 to 60 for steel, and 45 to 50 for aluminum alloy. Several types have been used satisfactorily. One, Epocast 9A, is a three component material using Flexibilizer T to adjust hardness. Successful tools have been prepared from the following formulation.

100 pbw Epocast 9A
100 pbw Flex "T"
12 pbw HN 951

In addition to this system, interest has focused upon a two component system where it is possible to adjust the ratio of hardener to resin. To achieve desired properties materials are carefully formulated to minimize age-hardening. Because of their rapid setting qualities they are limited to thicknesses of about ½ in., poured against metal.

Typical properties of a semi-resilient Epocast epoxy for punch facing are shown in Table II. For unlimited thicknesses, semi-rigid filled epoxies are preferred.

TABLE II

TYPICAL PROPERTIES OF SEMI-RIGID EPOXIES FOR PUNCH FORMS

Specfic gravity	1.25 g/cc
Tensile strength	300 - 500 psi
Shore D hardness	50/46
Hardness (after aging)	55/52
Bond strength to kirksite	500 psi
Ultimate elongation	60%
Effects of oil and grease	none

Epoxy capped metal tools have performed well in shaping metals for short production runs. Although some parts have been made from plastic faced drop hammer tools where the production runs into the many hundreds, more usually less than 50 pieces are shaped without tool rework. Difficulties may arise from several causes.

(1) Stretch of metal is sometimes severe enough to tear the semi-rigid plastics or rupture its bond to the base metal.

(2) Insufficient give in the epoxy to accommodate metal thickness, creates stresses which rupture the semi-rigid material. This is not so much an example of "softness" as absence of area for movement of the plastic.

(3) Addition of rubber pads inserted to set the radii of metal being formed may create stresses to rupture the plastics facing.

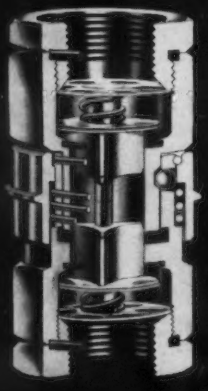
(4) Improper die design may create undue stresses on the face of the plastic.

However, there are various plus factors which favor the plastic faced drop hammer. These include: Ease and speed with which parts are prepared offer a saving over the costly and time consuming operations of grinding metal castings to dimensions. Plastic has the ability in many instances to smooth out wrinkles and irregularities in the metal being drawn across the surfaces. Scratching and surface marring are minimized.

Some manufacturers have gone so far as to replace metals in the construction of drop hammer tools. This is an entirely new approach, but a successful one instituted by the tooling division at Rohr Aircraft Co. Dependence on critical metals is eliminated. Furthermore, the more rigid abrasion resistant plastic (Epocast 7D) formula is used in the punch as well as the die facing; allowances are made to clear for metal thickness.

Epoxy drop hammer tools, whether they are metals, faced with plastic, or of the more recent all-plastic construction, have enjoyed wide acceptance by aircraft and missile manufacturers. Their use will no doubt continue.

✦



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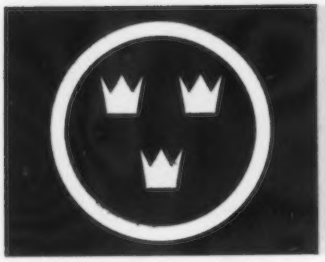
Circle 13 on Inquiry Card, page 83

By Ronald A. Cole



report from SAAB

Sweden's underground plant produces three types of aircraft, combines mathematical lofting and automation for repeat accuracy

When the Swedish manufacturer SAAB (Svenska Aeroplan Aktiebolaget) came into operation, the clouds of WWII were already over Europe. Till then the Royal Swedish Air Force had operated mainly foreign types of aircraft which had been purchased complete or manufactured under license.

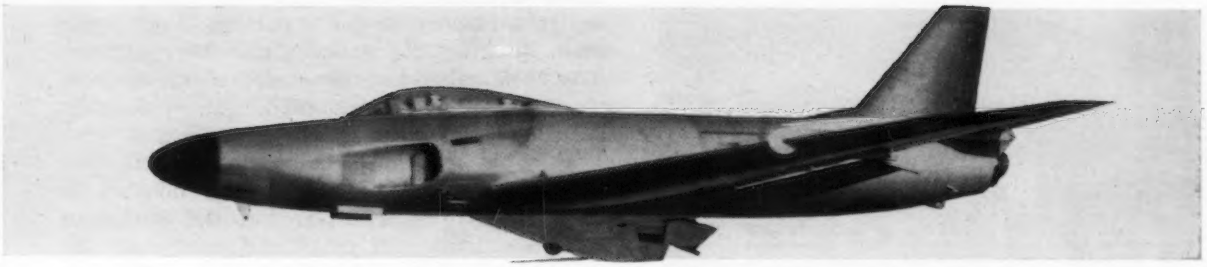
To provide reasonable safety against air attack, an underground factory was planned. A large two-story building of reinforced concrete was erected in a cavern blasted out of solid rock. Steps were also taken to provide underground hangars and storage for the Air Force fighter wings. Thus, the whole fighter defense force, from production to operation, was housed in bomb-proof shelters.

While planning the subterranean factory, allowance was made for possible psychological effects upon the workers. To this end interior decoration and novelties have been skilfully employed together with a first class ventilation system. The plant entrance is a pleasantly-decorated opening at ground level, with escalators leading down to a large entrance hall. Here, cloak rooms and restaurants are situated, and one may look at an imitation waterfall or a large aquarium. Much care and thought has been put into the indirect lighting scheme. During the short winter days a typical employee working in this windowless building may not see daylight from one weekend to another; the sky is dark when he goes to work and when he leaves it. A weather information board in the plant keeps employees posted on the atmospheric conditions outside.

Expansion of production and the increased complexity of aircraft has made the underground factory inadequate for dealing with many aspects of production. Although SAAB facilities have been augmented by large modern surface buildings, the underground factory still plays an important part in production planning. Significantly the most valuable tools are housed underground. All the heavy machinery, such as drop-hammers, presses, drawing machines and routers are situated on the lower floor. Thus their weight and vibration is transmitted straight to the rock foundation; the whole ground-floor is given over to the manufacture of sheet metal parts. With three aircraft in production; the Safir trainer, Lansen and Draken fighters, and the prospect of missile manufacture in the near future, this department has undergone considerable expansion.

Since wood is plentiful and cheap in Sweden, it has been used skilfully to make form tools for heavy stretch-presses instead of the more usual zinc alloy castings. Made of well-seasoned woods these are designed to resist compressive loading without significant distortion.

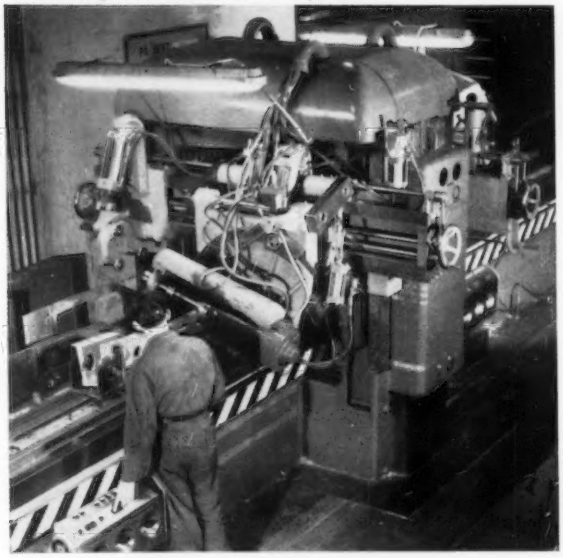
To deal with the jigging problem arising from the widespread use of castings and forgings, SAAB has adopted the Wharton Universal Jig & Fixture System with considerable success. This British invention consists of several standard parts in the form of small bed plates, grooved



blocks, sine bars, clamps, springs and distance pieces. All these fit together like the parts of an Erector set, and are used for building jigs and fixtures with ease. Once the run is completed, parts are dismantled and ready for re-use. Another feature which aids production is the use of large-scale drawings for ease of reference.

Design policy favors the elimination of parts which need large and costly machinery for their manufacture; apart from the cost and difficulty of housing large machines, these are regarded as strategic liabilities. In this direction, laminated rather than taper-rolled or machined skins are used; in the same token, integral skin-stringer panels are avoided. Such cost-reducing features are common in Europe and it seems that performance is not impaired by them. Some rather specialized small tools have been designed by SAAB engineers for the production of parts with complex contours. These have been placed in the production system only to assure a high degree of uniformity. The same engineers have derived some automatic relay control methods for machine tools, again with the aim of improving quality rather than volume.

The profile mill shown is of SAAB's own design. Spindle angle and height are variable; hydraulic control is used for loading the system to insure positive contact with profile.



Among the machines developed, there is a horizontal mill that produces profile and varying face-twist along the length of a spar. This has been used extensively in the fighter production program. A smaller machine, using the same principle of cam following, mills the continuously-varying angle on the face of forged fuselage-frames.

Mathematical Lofting

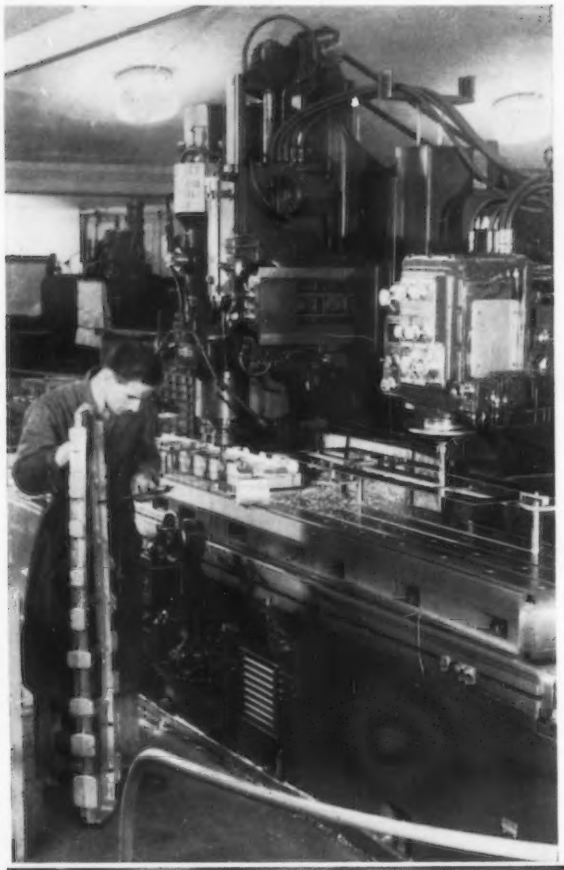
Mathematical lofting and layout techniques were adopted by SAAB when it first entered the jet-fighter field.

With their method, the entire surface envelope of the aircraft is divided into areas of which the section can be expressed as a mathematical curve. Thus, every point either on the surface or within the envelope can be expressed in relation to a system of co-ordinate axes. Mathematical determination of points can be carried out to within 0.01 mm (just under 0.0004 in.).

In the case of the Draken, which is a fairly small double-delta fighter of the tailless type, about 1 million points were calculated. This entailed about 20 million calculations which were carried out on an electronic brain and hand operated machines. Intake-duct surfaces are also treated by this method to control cross sectional area accurately.

continued on next page

Cincinnati Hydrotel vertical mill is used for profiling Lansen rib forgings.

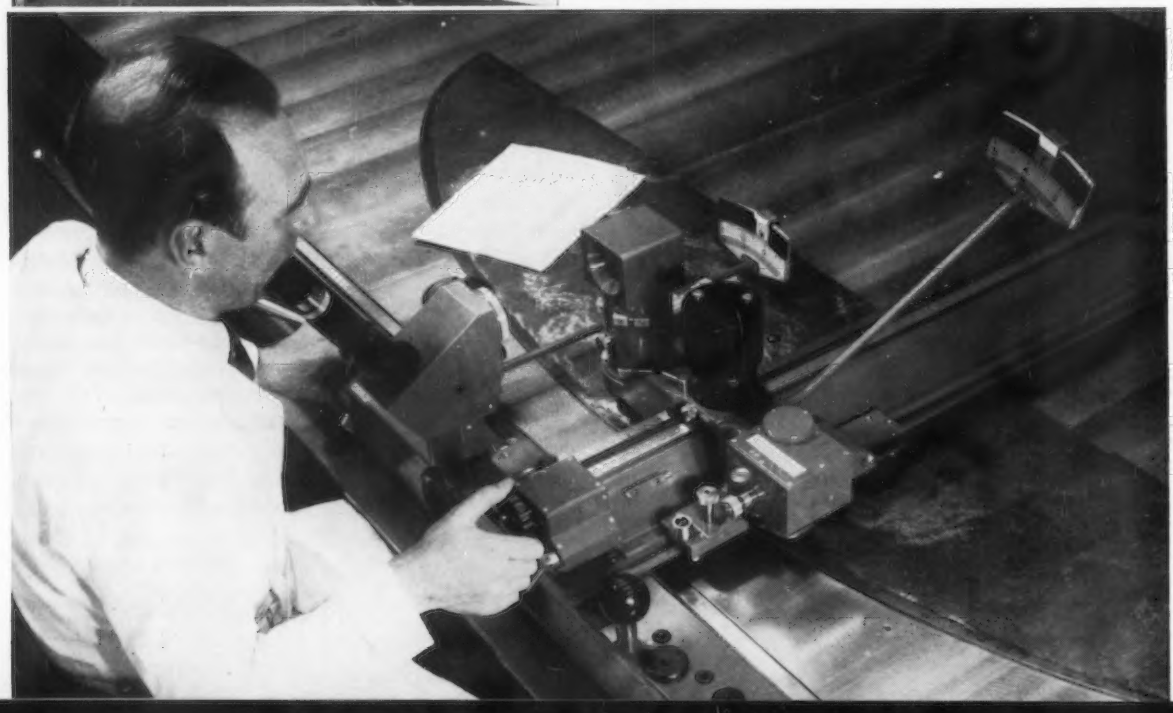


The Link

Using this method it has been possible to eliminate ordinary lofting methods for the determination of sectional shapes. Component contours are presented as a table of ordinates on a small drawing which also contains information about the major axes employed and their position on the aircraft. These figures are given to the designer responsible for a part so that he may make drawings for stressing and shop guidance. The same table may be passed to an operator working a "Coordinatograph," an instrument used for laying out templates and patterns.

This instrument is really the link that permits the mathematical accuracy inherent in the system, to be transferred to the workshops with a minimum of delay and manpower. In principle, the device may be likened to a T-square sliding along the edge of a drawing board. It may be adjusted to any point along the edge of the board, say the X axis, while a saddle on the blade can be similarly positioned in the Y axis. The saddle carries a plunger which can hold either pencil lead or a sharp metal scribe. When a button is pressed the scribe snaps down to make a small mark on either paper or metal. Hand wheels are turned to position the saddle and blade against scales marked along both axes. Optical viewers are used to assist accuracy of setting. Points can be located to within ± 0.001 to 0.002 in.; much faster than they could be positioned by hand. If necessary, the Coordinatograph may be operated in reverse. A small optical sight located on the saddle is used to locate points on an existing curve and ordinates be read off.

Operator is seen using Coordinatorgraph to check contour template.



The Lansen—Design & Production

The SAAB 32 Lansen is primarily a two-seat, all-weather, attack aircraft which can be used also for photo reconnaissance. One version, the 32B is intended for night fighting and is fitted with a more powerful afterburner. Air-to-air, air-to-surface, or conventional weapons, may be carried by the attack version in addition to the four 20mm cannon mounted in the lower nose. Several hundred of the attack version are now in service with the Royal Swedish Air Force. Performancewise, there is no doubt that the Lansen is equal to similar machines produced by other nations, or perhaps somewhat better from an operational point of view.

Normal take-off weight is about 22,000 lb, but the Lansen can operate well in excess of this figure. Maximum speed at sea level is over 700 mph, and at higher altitudes more nearly approaches Mach 1. Range is quoted as several hours, and this is taken to mean somewhere in the region of three or more. It is this feature which makes the aircraft suitable for night fighting and interdictor duties.

Power is supplied by a Swedish-built Rolls-Royce Avon, different versions being used. The attack version uses the RA.7R with a standard afterburner which allows a maximum thrust of 10,000 lb; the night fighter version uses the series 200 engine with a Swedish design of afterburner which can boost power to about 14,000 lb. This afterburner is characterized by more bulky proportions and an eyelid-type two-position shutter.

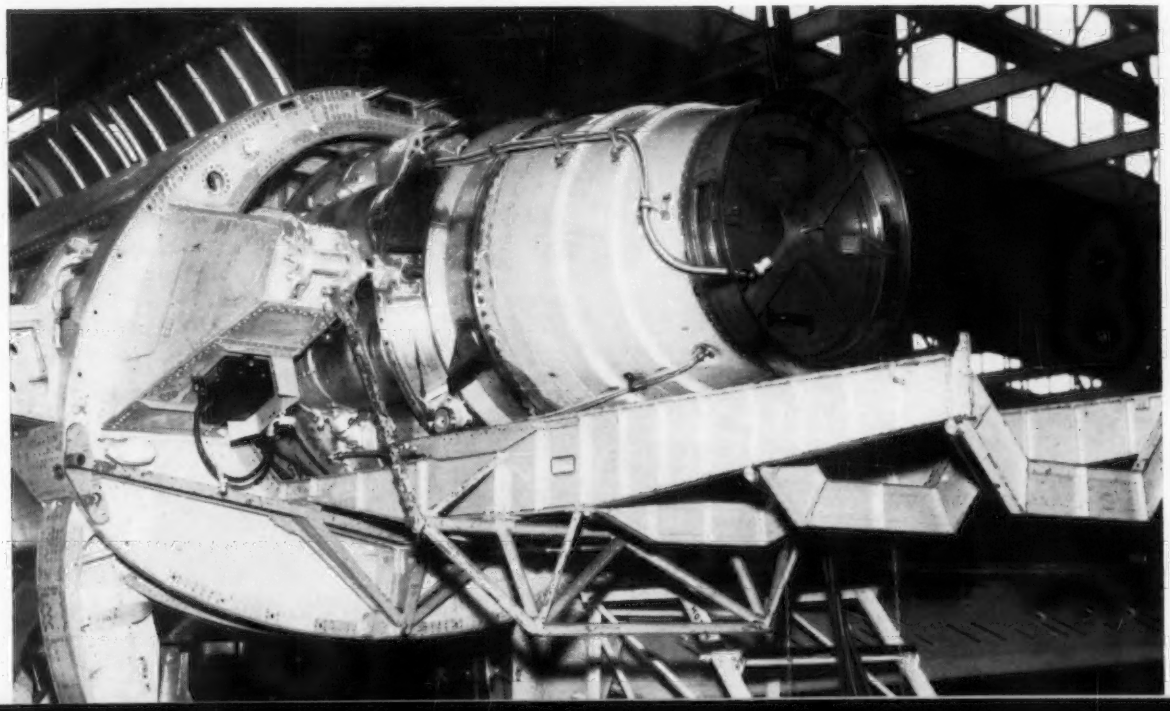
Generally, the airframe structure is along conventional lines with perhaps more individual pieces than usual. This fits in with the general order of small and simple production facilities without the use of special equipment. In size, the aircraft is about average for Europe, being slightly smaller than the standards set by American manufacturers.

Fuselage

The fuselage is split into front and rear sections about a ring frame situated just aft of the engine compressor casing. Each part is produced as a separate entity complete with equipment installed before joining takes place. All the fuselage nose as far back as the cockpit front-wall houses radar and radio equipment as well as cameras in the case of the 32C, reconnaissance version. A scanner is situated right forward under the glass fiber nose fairing. Ammunition boxes built into the fuselage side feed down to the cannon breeches; the fuselage skin hinges open to give easy access for reloading. The steerable nosewheel retracts about hinge brackets on the bottom of the cockpit front-bulkhead, and lie under the radio deck in the nose.

Side intakes are mounted slightly behind the cannon breeches and on the lower part of the fuselage. In type, they may be described as semi-flush; their sunken nature insures that the total intake area does not add to the fuselage cross section. Being in a low position slightly ahead of the wing leading edge they are unobstructed

Engine is seen mounted in fuselage prior to withdrawal of engine installation cradle.

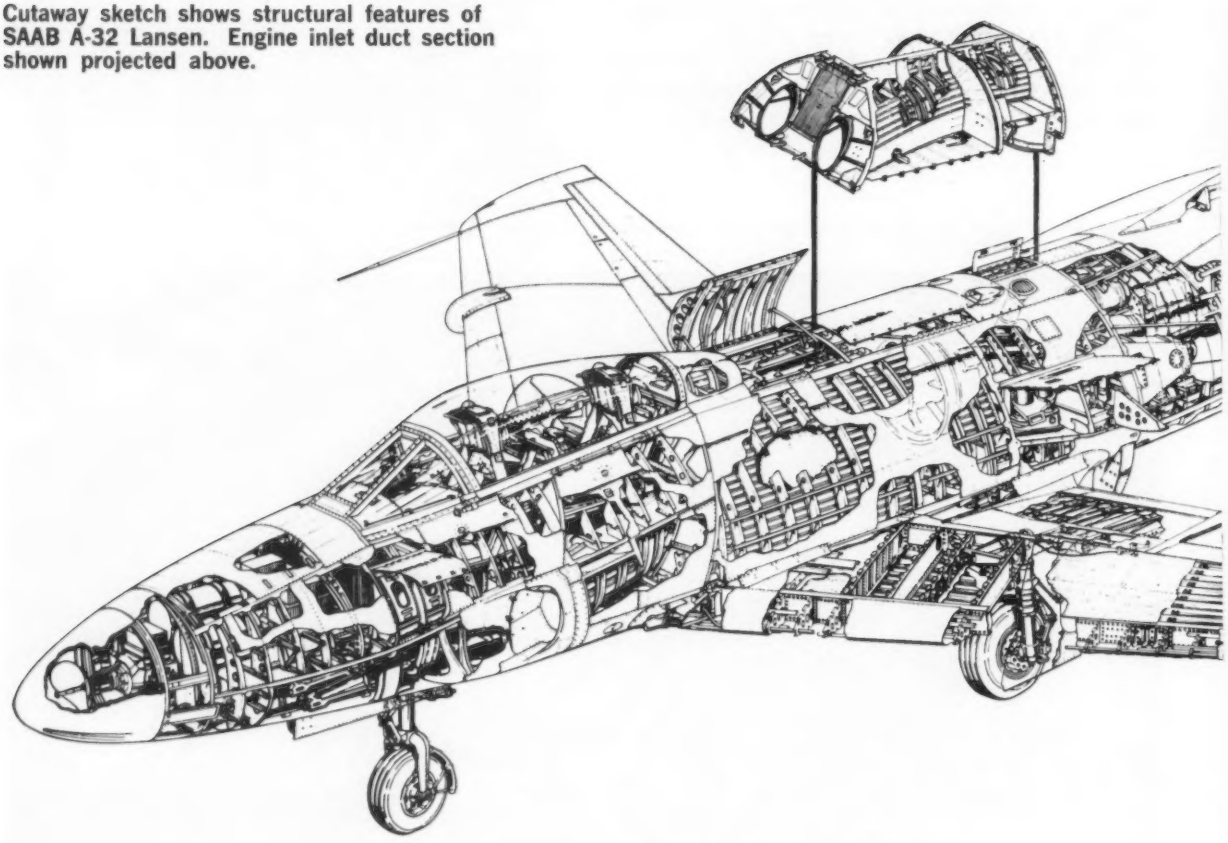


Box-section cantilever seen in right foreground carries engine weight and thrust. Perforated structure under the arm of first mechanic is dive brake; another dive brake is seen hanging down below the first one.

at high angles of attack. A small boundary-layer bleed ejects the air from a slot in the fuselage side just above the intake. Ducts running from the intakes curve in towards the centerline where they merge just aft of the rear cockpit bulkhead. These ducts are stoutly constructed with thick skin, flush riveted to hat-section hoop stiffeners. An interesting point here is that interior surfaces are also mathematically lofted as is the rest of the skin envelope.

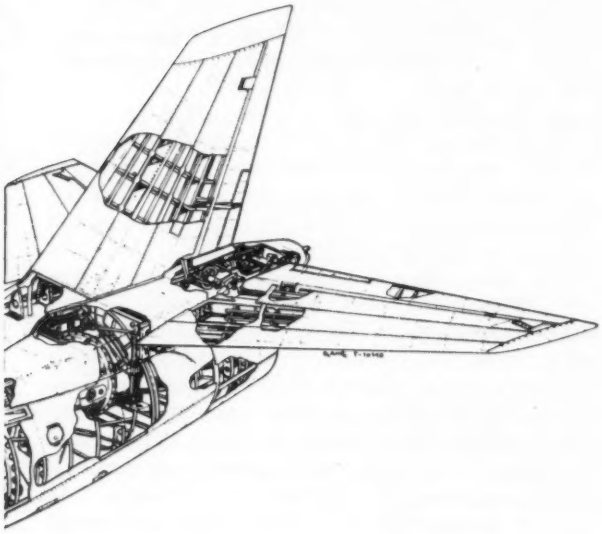
Construction of the front-fuselage back to the rear cockpit wall consists of pressed and built-up frames with four longitudinal members on the skin line, and two internal shear beams. The top pair of longitudinals are integrated with the canopy rails and are very heavy members. The lower pair run along the top of the intake ducts and the right forward support the radio deck with the aid of the shear beams. Behind the cockpit there is a tank bay which straddles the wing center section. Here a matrix of

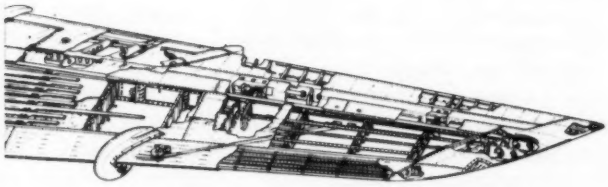
Cutaway sketch shows structural features of SAAB A-32 Lansen. Engine inlet duct section shown projected above.



pressed and notched frames carries a smooth internal skin for the saddle tanks which fill the space between this wall, and the air duct running through the center. Doors on the top fuselage give access to the tank plumbing and breather tubes.

This bay ends at a bulkhead which coincides with the engine intake position; the remaining section extends to the joint ring and is the compressor bay. Heavy box-section cantilevers project from the ring on either side to carry the engine thrust-trunnions. The inner skin of the boxes extends forward to the tank bay as a shear web and the space between it; the outer skin is used to house generators and hydraulic tank on the left side and conditioning equipment on the right. Air brakes which open out as flat plates normal to the airstream are also attached in this region by means of forged hinge-brackets. A horizontal floor under the tank and compressor bay provides transverse shear rigidity.





The Wing

The low aspect-ratio wing of the Lansen has a sweep of 35 deg at the ¼ chord line. It is mounted on the fuselage underside via five pick up points. Structurally it consists of a main stress-carrying box built around a front and rear spar with a stiff D-section leading edge and a lighter trailing-edge shroud.

Front and rear spars are of the tension-field type with extruded stiffeners riveted to the web. Like the hat-section spanwise stiffeners these are milled along their length to taper the structure. The spanwise stiffeners are closely spaced and are riveted to the outer skin through the back of the channel, while an inner skin is riveted to the two flanges. Tankage within the wings is of the integral type. Over the inner section most of the ribs are forged members; some with Warren truss while others have vertical straps between the top and bottom to which substantial diaphragms are fixed. Facing the attachment pads on these ribs and contour milling the profile is done on vertical Cincinnati Hydrotel copy mills.

The wings are made in half spans and joined by bolting through heavy strap-plates across the top and bottom skins. Ends of the spanwise stiffeners, which have been left oversize, are connected via the strap plates and become continuous across the span. All rivet heads and exposed skin edges are surface milled to give a very smooth finish.

Controls & Cockpit

All control surfaces are power operated, but in the event of an emergency, it is possible to neutralize the system and revert to manual control. The area-increasing fowler flaps run out on three rails automatically assuming the required angle of droop; small catches on their top surface provide stops to the inward travel and are used to lock them home.

Cockpit accommodation is for two in tandem, the pilot and crewman. Each man is equipped with a lightweight ejector seat of SAAB patent, design and manufacture. Either side of the seat head-piece there is a small transparent plastic wing which improves seat stability during ejection. A one-piece molded windshield between the crew man and the pilot protects the crew man from the slipstream blast when the canopy is jettisoned.

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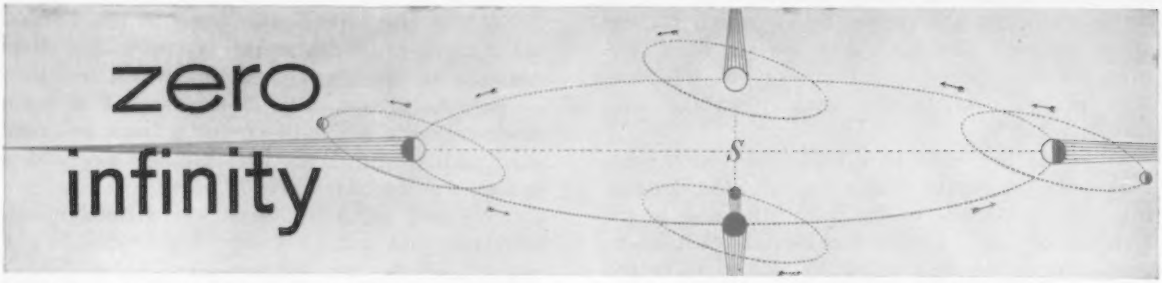
NEXT MONTH
Look for the Missile Handbook!



This department is created to encourage thinking in new dimensions; thinking that is free of the often constraining influence of immediate difficulties. Technological progress is to a great extent based on departures from the conventional or the status quo. That which is considered illogical or impossible to accomplish, has and always will be so only within the limited compass of accumulated knowledge up to a particular date. Speculative thinking is man's most precious asset. It is hoped that this department will provide an outlet for such thinking and will serve to stimulate further ideas. The implications of the symbolism for this department head are that: while the immediate worth of a concept may range from nil to infinity, its true value will only be determined in the ultimate.

rates and tariffs for space exploration

will delivery of great payloads to space require international cooperation and combination of resources?

by Dr. Saxe Dobrin,
consultant, North Hollywood, Calif.

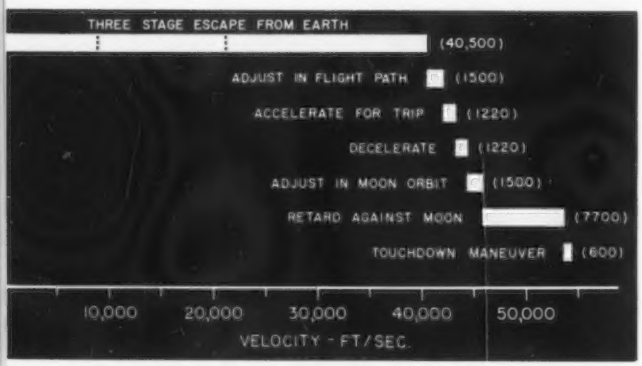
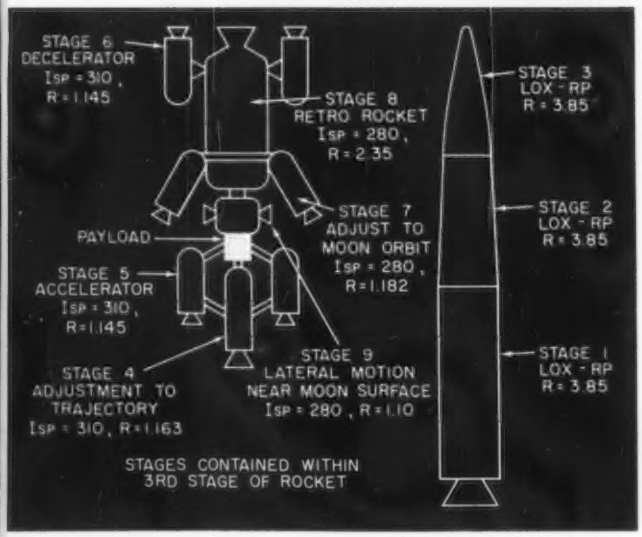


Fig. 1. Cumulative energy requirement for a landing on Moon.

Fig. 2. Schematic missile assembly, for a 25,000-lb payload delivery to outer space, illustrates staging configuration needed for maneuvering sequence.



During the next decade the activity in space exploration will grow to become a significant portion of the entire world economy. Within two years glide vehicles will take men to the fringe of the Earth's atmosphere, and a few years later man-carrying capsules will orbit the Earth. We anticipate building a permanent space station and also exploring the surface of the Moon.

To accomplish these tasks many packages will have to be sent off the Earth: short-lived instrument packages for exploratory studies and scientific tests; long-lived instrument packages for monitoring the environment in space; and shipments of bulk materials, as well as, the craft designed for occupancy.

These shipments will go to different destinations and will be sent at different times, but they will find it convenient to share a common "transportation system." The "transportation system" may comprise several classes of equipment and several originating points. Shipments may go along several routes.

In sum total, the plans for a space program will take on the aspects of the plans for a

TABLE I

Mass Ratio Required for Each Maneuver of a Mission

	Velocity, Ft/Sec	Specific Impulse, Sec					
		200	240	280	310	350	400
Boost Out of Atmosphere	26,500	—	—	—	16.5	—	—
Orbit	29,500	—	—	—	—	—	—
Escape	40,500	—	—	—	57.5	36.5	24.5
Adjust in Orbit	1500	—	—	—	1.163	1.142	1.124
Accel. for 10-day Moon Trip	1220	1.210	1.172	1.145	1.13		
Accel. for 2-day Moon Trip	6000	2.52	2.175	1.946	1.825		
Decel. for 10-day Moon Trip	1220	1.210	1.172	1.145	1.130		
Decel. for 2-day Moon Trip	6000	2.52	2.175	1.946	1.825		
Accel. for 400-day Mars Trip	1160	1.198	1.162	1.138	1.123		
Decel. for 400-day Mars Trip	1160	1.198	1.162	1.138	1.123		
Adjust to Moon or Mars Orbit	1500	1.263	1.214	1.182	1.163		
Retro to Moon	7700	3.31	2.70	2.35	2.16		
Soft Moon Landing	Arbitrary	1.1	1.1	1.1	1.1		
Soft Mars Landing	Arbitrary	1.1	1.1	1.1	1.1		

regional railroad. Some shipments are essential to the regional economy but by themselves cannot bear a proportionate part of the total expense. They are granted reduced rates. In like fashion, some of the space projects, small in number and requiring special attention, will be key items in the space program, but cannot by themselves justify development expenditures. Thus, a schedule of rates and tariffs must be created to set a fair price for each class of shipment.

The big cost element, of course, is the delivery of packages to a point beyond return to Earth. Depending on the destination, additional charges must be made for each required maneuver. An express shipment to a specific address on the Moon, for instance, requires seven maneuvers, including the launch from Earth. A slow freight shipment for general delivery on the Moon can be done with five maneuvers.

In the overall space program, the highest freight classification is carried by short-lived instrument packages for tests and scientific studies. These items must be transported early in the program, and they are to be delivered to special destinations. Using newly-developed equipment or compromise design assemblies, these packages are subject to a high risk of loss or delivery to a wrong destination. The scientific instrument assemblies, which will weigh 100 to 1000 lb, can be delivered to most destinations with existing rocket engines. However, because the packages are small, the unit delivery cost will be high.

Long-lived instrument packages will weigh 3000 to 10,000 lb, most of the weight being instrument power-supply. With a nuclear reactor and power plant, packages in this category can be equipped with ion propulsion and can navigate among the heavenly bodies. These payloads are entitled to a lower freight-classification, because of their larger size.

Shipments of freight will command the basic freight-classification because they can be

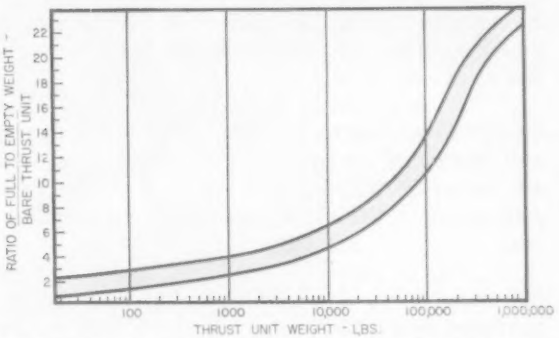


Fig. 3. Ratio of full to empty weight (mass ratio) of thrust units is shown extending from the smallest to the largest ones on drawing boards.

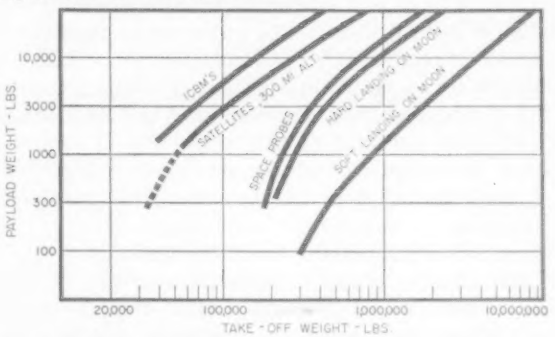
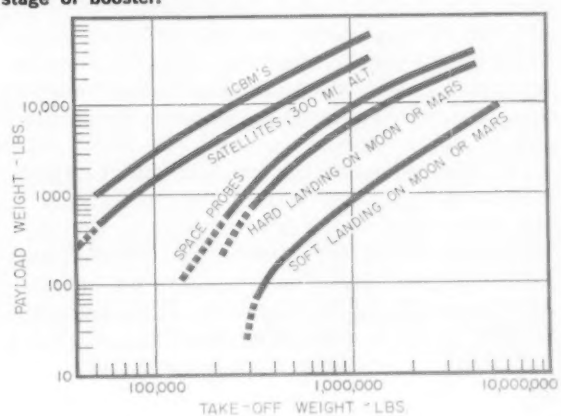


Fig. 4. Payload capabilities of missiles with three boost stages using LOX-RP combination.

Fig. 5. Payload capabilities of missiles using high-energy (fluorine-hydrazine) propellant in second and third stage of booster.



delivered in full-payload quantities. In this category will be the materials needed for construction of an orbital space station. Present plans for space stations indicate practical unit payloads of 15,000 to 25,000 lb.

Vehicles for human occupancy will also weigh 15,000 to 25,000 lb, although only a part of the amount will be allotted to the men and their domestic needs. There must also be provision for a return to Earth. The cost of the return vehicle and its propellant must therefore be included in the passenger rate.

Each planet-to-planet maneuver requires energy which can be rated in terms of mass-ratio and propellant specific impulse. The size of missile needed for any payload can be estimated by a summation of the energy needed for each maneuver.

Fig. 1 shows the cumulative energy requirement for a Moon landing. For rate-making purposes each maneuver can be considered as one stage, except for launching from the Earth, where engineering considerations dictate three stages.

Fig. 2 is a schematic missile assembly. A 25,000-lb load delivery to outer space requires a gross takeoff-weight of 1,000,000 lb. Table I shows the mass ratio allotted to each maneuver of a mission. The sheer size of the first stage (70 to 80 per cent of the total weight) dictates that its propellant be inexpensive and abundant. Liquid oxygen with kerosene fills this specification.

The maneuvers in outer space do not require much energy. For each maneuver, only 10 to 20 per cent of the body weight need be spent for propellant, except retardation against the gravity of the Moon or Mars. This maneuver calls for more than half of the weight to be discharged.

However, since the thrust units must be carried in the early part of the flight to be available for the final steps, successively larger stages are required; only a small fraction of the assembly can be useful payload. The larger the payload, however, the more favorable is the payload ratio.

Fig. 3 shows the ratio of full to empty weight of thrust units from the tiniest sizes to the largest ones on the drawing boards. The sizes which are needed to maneuver the intended payloads in space, unfortunately, have an unfavorable proportion of inert weight. However, there is little merit in combining the stages to get a more favorable ratio, because the single thrust unit then carries inert weight through the successive maneuvers.

TABLE II

Freight Charges for Shipments to Space Destinations, $/lb

	Cost of Missile per lb	Short-Lived Instrument Package 100-1000 lb	Long-Lived Instrument Package 1000-10,000 lb	Freight, and Craft Carrying People 10,000-30,000 lb
300-mi orbit	$10	$1333	$500	$400
	15	2000	750	600
	20	2666	1000	800
22,000-mi orbit	10	3333	1200	800
	15	5000	1800	1200
	20	6666	2400	1600
Space Probes	10	6666	1600	1600
	15	10,000	2400	2400
	20	13,333	3200	3200
Moon Landing	10	30,000	8000	—
	15	45,000	12,000	—
	20	60,000	16,000	—

With a specified payload and destination, Fig. 3 and Table I can be used to calculate the missile size needed. This has been done for two series of propulsion systems. Fig. 4 shows the requirements if LOX-RP is used in the boost stages and a storable liquid is used for the final stages. Fig. 5 shows the requirements if the propellants are: first stage, LOX-RP; second and third stages, high energy (fluorine-hydrazine) and subsequent stages a storable propellant.

Figs. 4 and 5, thus give a basis for establishing the price per shipment. At the present time it is almost impossible to put a fair price on a large missile since our experience so far has been developmental, not manufacturing. Cost estimates of large missile assemblies, including propellant, come to about $15/lb. A shipment of 20,000 lb into orbit, which requires a missile weighing 1,000,000 lb, will therefore have a transportation charge of $15,000,000 or about $750/lb. Table II gives the delivery price per lb of payload for several space destinations.

Some of these rates may seem unreasonably high for the early scientific tests, but the importance of such tests will extend to subsequent developments.

Responsibility for sound policies and administrative practices will be vested in the National Aeronautics and Space Administration. At the same time that the NASA plans for its "transportation system," it will also have to plan its shipment schedules and the tariffs it will charge.

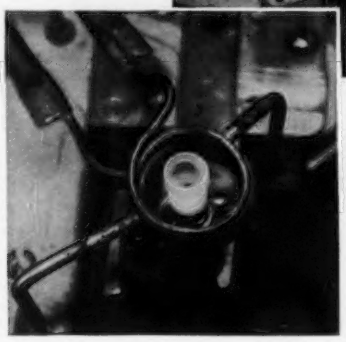
For the engineering of the "transportation system," NASA can call upon the industrial contractors who supplied military missiles. However, for advice on shipment schedules and tariffs, NASA shall have to call upon the experience of other segments of our economy.

✦

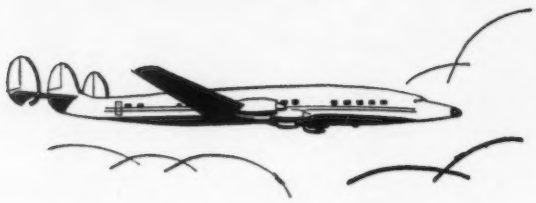
B-1 Flux is particularly effective in removing refractory oxides such as those formed in stainless steels.

Operator fits preformed ring of BRAZE 541 prior to fluxing. This is a hose and tube assembly for an oil line.

Here operator applies gas-air torch, hand-feeding BRAZE 541 to joint.



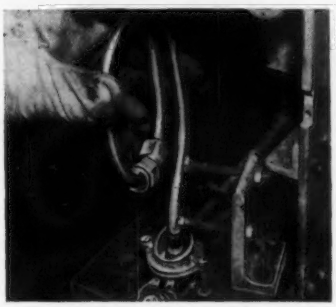
Oil-bearing unit under induction heating.



Here's How Stainless Steel Fuel Systems Benefit From

HANDY & HARMAN SILVER BRAZING

Tube Processing Corporation, Indianapolis, Indiana, makes aircraft and missile fuel systems and, if anything has to be more failure-proof than a fuel line assembly in an airplane, you name it. The units shown here are made of 410 stainless steel tube and 321 stainless steel fittings; when they're joined, they must be joined permanently. Exhaustive tests, including X-ray, pass on each assembly before final acceptance.



Operator placing oil line (of another type) in induction heating ring.

To meet all requirements: strength, ductility, liquid and airtightness, production speed and economy, Tube Processing uses Handy & Harman's special alloy BRAZE 541 (formerly Alloy 4772) and HANDY B-1 FLUX.

Developed strictly for brazing stainless, BRAZE 541 is one of many Handy & Harman brazing alloys—both standard and special—made to do a specific job and do it better than any other metal-joining method.

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An exclusive additional benefit is Handy & Harman's application Engineering Service. This is a service that exists to show you how these benefits can best be applied to your product. We invite you to take advantage of both Handy & Harman Brazing Alloys and Engineering Service.

GET THE FACTS

Technical Bulletins T-1 and T-2 give the general characteristics of silver brazing alloys plus the compositions, melt and flow points of 32 separate alloys. Write for your copies.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

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Circle 14 on Inquiry Card, page 83

AIRCRAFT & MISSILES MANUFACTURING DIGEST OF RECENTLY PUBLISHED TECHNICAL MATERIAL

producibility REVIEW

PRODUCTION

FOR HIRE: PLASMA COATING AT 30,000 F. *Amer. Mach.* (December 15, 1958), 1 pp. Brief description of new production method, developed by Linde Co., whereby tungsten is sprayed on missile nose cones.

NON-DESTRUCTIVE TESTING (Part IV.) *Acft. Prod.* (December 1958), 19 pp. Radiographic inspection of aircraft structures discussed in detail, as practiced by Vickers-Armstrong.

SUPERALLOYS FORMED WITH EXPLOSIVES. P. J. Wolf. *Tool Engr.* (December 1958), 5 pp. Various ramifications presented as applicable to the production of aircraft and missile parts.

ROTODYNE ROTOR-BLADE (Part II). *Acft. Prod.* (December 1958), 6 pp. Tooling for the stainless-steel ribs and the airfoil skin, also blade assembly procedure are described.

MICROINCH TOLERANCES WITH ELECTRIC DISCHARGE MACHINING. W. F. Wagner, *Space Aero.* (January 1959), 2 pp. Equipment, methods, and applications discussed as practiced at Northrop.

BOOKS RECEIVED

WELDING HANDBOOK (Fourth Edition), Edited by A. L. Phillips. *American Welding Society*, 1957. 555 pp. $9.00. This is the first section of a five-section comprehensive work. A succeeding section will be published each year and revisions of each section shall follow to reflect advances in current practice. Tabulated data, nomographs, photomicrographs, and line drawings are used throughout; extensive bibliographies amplify each chapter. Chapter headings are as follows: standard welding terms, general engineering tables, fundamentals of welding metallurgy, properties of joints, thermal and mechanical treatment of weldments, design of joints, estimating costs, inspection, testing methods, quality control, and safe practices.

AIRCRAFT AND MISSILE PROPULSION (in three volumes). M. J. Zucrow. *Wiley*, 1958. Written for the student and the practicing engineer with an understanding of the basic principles and operating characteristics of aircraft and missile engines. Included are many illustrative, as well as exercise problems with answers, reference tables, and references for further study at the end of each chapter.

VOLUME I (538 pp., $11.50), discusses the thermodynamics of fluid flow and its application to propulsion engines.

VOLUME II (636 pp., $13.00), presents the analysis of cycles and performance characteristics of the gas turbine, the turboprop, the turbojet, the ramjet, and of rocket engines.

VOLUME III (to be published.)

THE INHABITED UNIVERSE. K. W. Gatland and D. D. Dempster. *McKay*, 1958. 182 pp. $3.95. Written in language any intelligent layman can understand, this book provokes the reader to view the universe through some recently-opened windows. It discusses the mechanics of living matter, and in the light of present-day knowledge, appraises the likelihood of life elsewhere in the universe. Scientific and philosophical criteria are presented whereby man may evaluate himself in the eve of his greatest adventure.

SOLID PROPELLANT ROCKETS (second stage). A. J. Zaehringer. *American Rocket Co.*, 1958. 306 pp. $8.00. An introductory handbook for students, scientists and engineers. Thoroughly illustrated and documented with references and bibliography, the book is subdivided into the following chapters: introduction and history, interior ballistics, processing, exterior ballistics, static testing, dynamic testing, applications, propellant technology, hybrid rocket, and safety. A ten-page glossary is also included.

COIL WINDING (second edition). W. Querfurth. *Geo. Stevens Mfg. Co.*, 1958. 192 pp. $5.00. Winding machines, associated equipment, and techniques are illustrated and explained in detail. Included are 2700 gear ratios for universal coil winding. Chapters are devoted to single-layer windings, multi-layer windings, universal-type winding, progressive-universal winding, toroidal windings, and yoke and armature winding.

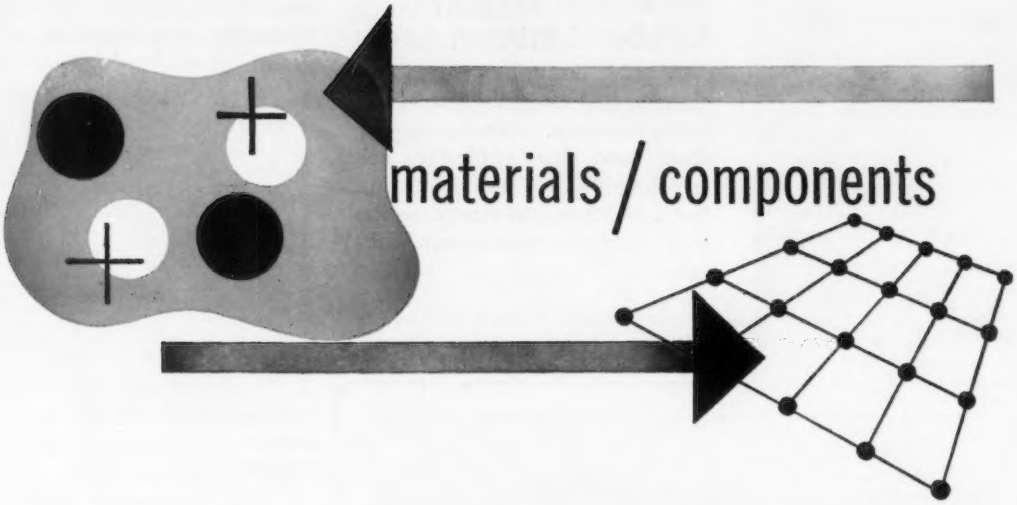
REVIEWED IN THIS ISSUE

Periodicals and Papers

Acft. Prod. Aircraft Production (British)
Amer. Mach. American Machinist
Tool Engr. Tool Engineer
Space/Aero Space Aeronautics

Books Received

Aircraft and Missile Propulsion (in three volumes) Wiley
Coil Winding (second edition) George Stevens Mfg. Co.
Solid Propellant Rockets American Rocket Co.
The Inhabited Universe McKay
Welding Handbook American Welding Society



MACHINE SPRINGS GOOD FOR PRECISION INSTRUMENT USES

A line of precision compression springs is available for applications where conventional springs prove inadequate.

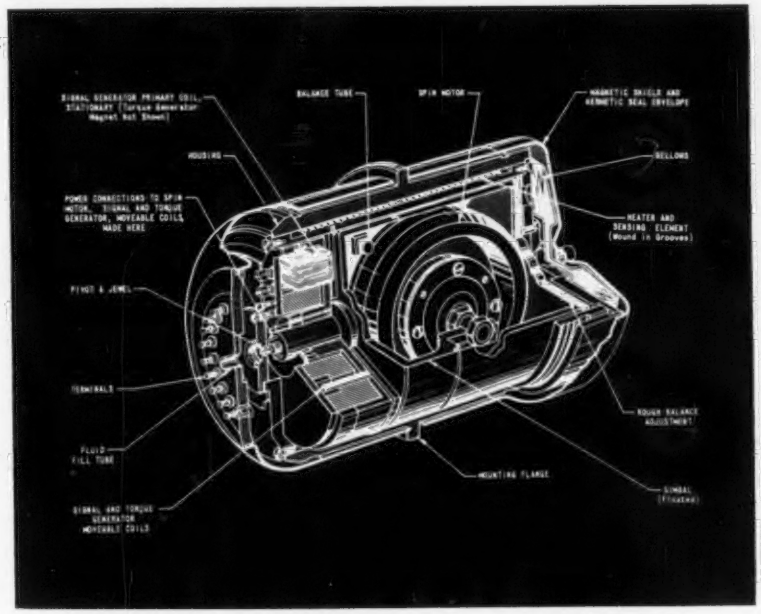
Designed to meet the requirements of instrument and control designers, the new springs are manufactured in two basic classes: "herringbone" and "gimbal."

Both classes are machined, heat treated, and precisely ground to offer square ends, tight control of free length, and exact matching of specified spring rate.

Construction eliminates the twisting or turning moment between the end faces that can produce shifts. Another advantage is the uniformity of spring rate from zero load to max.

Consolidated Controls Corp.

Circle 55 on postcard for more data



INERTIAL SYSTEM GYRO HAS 1000 HR. LIFE

A new hermetic integrating gyroscope (HIG) was designed specifically for long-range, high-accuracy inertial guidance and navigation systems.

The gyro, designated GG37B, exceeds drift rate, stability features and ruggedness of present-day gyros.

Minneapolis-Honeywell Regulator Co.

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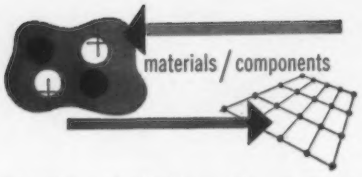
SUPER-PURE CHROME HAS HIGHER DUCTILITY

A super-pure chromium, Iochrome, which contains no impurity in quantities greater than 10 parts per million, has been developed.

It is produced by means of an iodide decomposition process.

Iochrome has demonstrated a greater degree of ductility than any chromium pre-

continued on next page



viously available. In room temperature tensile tests on wrought material from an arc-cast Iochrome ingot, a 44 per cent elongation has resulted.

Chromalloy Corp.

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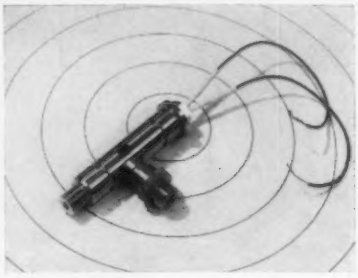
VALVE ACTUATED BY EXPLOSIVE CHARGE

Of normally-closed design, a new propellant-actuated valve houses a laterally moving spool and the explosive cell which drives it. The inlet fitting has a blind end to eliminate the possibility of preactuation leakage.

Design is such as to permit use of a simple reload kit for re-usability in either systems test and checkout activities.



Propellant cells can be provided in either single or dual bridge-wire types to meet reliability requirements.

Beckman & Whitley Inc.

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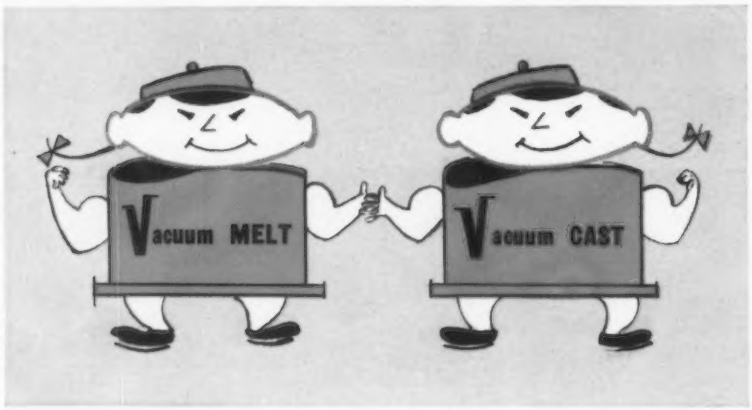

MISCO INTRODUCES "DOUBLE V"

A technique to enhance the properties of metals demanded by the aircraft, missile and space age vehicles.

"DOUBLE V" signifies the manufacture of cast components using *vacuum melted primary* ingots subsequently *remelted, poured in vacuum,* using investment or MONO-SHELL molds.

Misco engineers have designed vacuum equipment which permits continuous operation for High Volume Production. Charging of primary ingots, introduction of MONO-SHELL molds, melting and pouring, are carried out in vacuum through the ingenious use of charging locks.

For maximum benefits, melting temperatures are controlled optically and a vacuum pressure of 10 microns or less is maintained on mold and metal during pouring.

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NEW SYSTEMS EXTEND CAMERA PERFORMANCE

The N-9 gun camera long noted for its compactness and reliability now incorporates an improved 100 ft magazine, a twin-timing system, a unique frame-event correlation device, and a periscope lens assembly with 360 deg rotation.

A new 50-ft magazine permits daylight threading operations.

Traid Corp.

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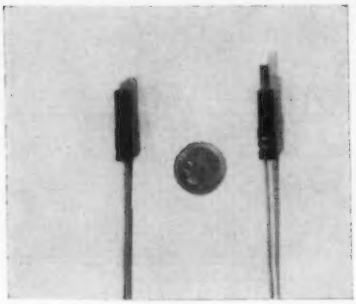
TINY PISTON MOTOR HAS ¼ IN. DIAMETER

A miniature, squib-actuated piston motor to provide positive displacement for the performance of mechanical work should be of interest to designers of missiles. The motor has ¼-in. diam and 15/16 in. length.

Actuated by as little as 100 ergs at 1.5 v, or 0.2 amp, the motor is capable of providing 20 lb of thrust.



The motors function from —65 to 165°F and will withstand 20,000 g's shock and acceleration. Shelf life is several years.

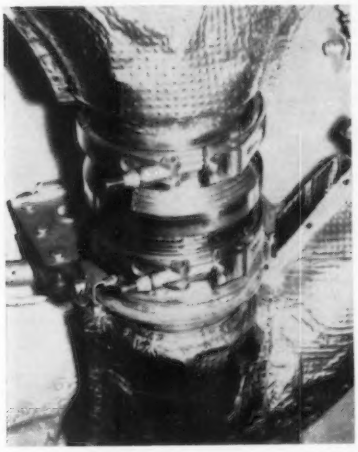
Ordnance Material Dept.
Atlas Powder Co.

Circle 53 on postcard for more data

AIR DUCT JOINTS ARE SELF-ALIGNING

Patterned after "Monoball" two-piece design self-aligning bearings, new "Flexhot" Air Duct Joints have 10 deg self-aligning and 360 deg rotation.

Joints are available in bore size of 5 in. with operating



pressures of 110 psi and a temperature operation of 550°F. Other bore sizes on request.

Southwest Products Co.

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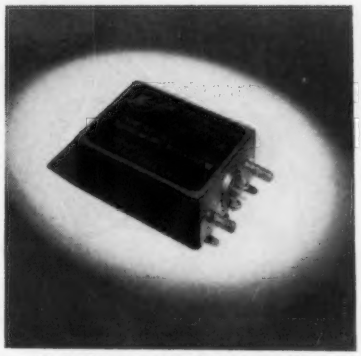
MINIATURE AMPLIFIER TRANSISTORIZED

A miniature completely transistorized servo amplifier is capable of delivering a power of 2.5 watts.

Weighing only 1½ oz, the amplifier measures 1½ x 1⅛ x 9/16 in. and operates through a chassis operating temperature range of —55 to 110°C.

Kearfott Co., Inc.



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ALL THE PRODUCTION YOU'LL EVER WANT — ALL THE PRECISION YOU'LL EVER NEED
BUT MY WORK INCLUDES THE MANUFACTURE OF—
I KNOW! AND YOU CANNOT POSSIBLY BUY A BETTER MACHINE FOR THE JOB THAN—
THE HAMILTON No. 1-B PRECISION SMALL GEAR HOBBING MACHINE
INVESTIGATE IT! YOU'LL SEE!
SPUR GEARS, WORM GEARS, (up to 6" O.D.) and SPIRAL GEARS
WORMS
SPECIAL TOOTH FORMS
GEAR SECTORS
PINIONS
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and BEVEL GEARS (up to 3" O.D.)
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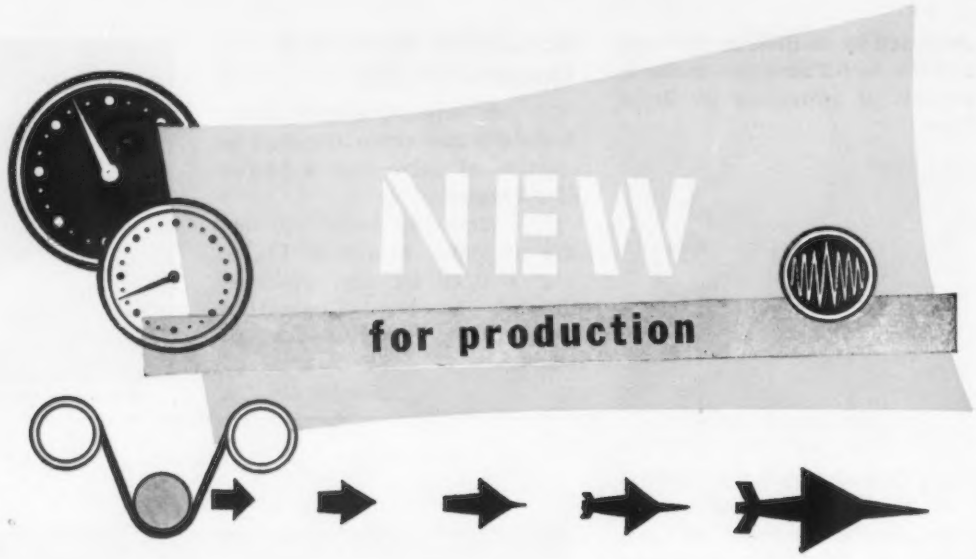
Circle 16 on Inquiry Card, page 83



PLASMA ARC TORCH

This plasma arc torch fabricates shapes and applies coatings which can withstand temperatures above 5000°F.

Process harnesses the highest controlled temperatures ever used in industry—up to 30,000°F. Torch is less than two in. diam., can melt the toughest materials known to man.

In addition to experimental rocket and missile parts of pure tungsten or tungsten-coated graphite, the new torch has already been used to produce high density tungsten crucibles for metallurgical purposes, special parts for nuclear work, sensitive electrical contacts, and electronic components and X-ray targets of superior density.

So flexible is the method that pure tungsten, molybdenum, zirconium, tantalum, hard carbide materials, and even precious metals, including platinum and palladium, have been used successfully.

Illustration shows work on nozzle liner for rocket engines. Successive coatings of tungsten are applied on a spinning mandrel at near-sonic speed. Metal comes from torch in fluid or plastic state; is cooled by sprays of carbon dioxide gas.

Accuracy of plus or minus two thousandths of inch can be maintained at will. Where formed parts are not required, the torch coats virtually any material, including reinforced plastic, with a widest vaviety of metallic or refractory platings.

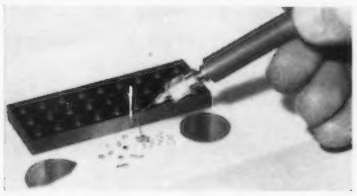
Metal or substance to be worked is prepared in either wire or powder form and is then passed through an intense arc struck inside the torch.

Material, converted into its fluid or plastic state, is carried out of the torch by inert gases flowing at high velocity, finally deposited on the part with such force that a firm bond results.

Linde Co.
Div. of Union Carbide Corp.

Circle 59 on postcard for more data

VACUUM SYSTEM USED FOR HANDLING PARTS



"Vac-U-Grip" tool was developed for applications where smallest size parts have to be handled in a fast, easy, and accurate manner. It eliminates the damage to delicate components often experienced with tweezers.

Tool is connected to the vacuum system by a suitable length of lightweight, flexible, plastic tubing. A solenoid-operated valve between the vacuum line and the pick up element is controlled by a foot-operated switch allowing operator to release the suction when the part is correctly positioned.

System can be furnished in single or double stations each including tools, interchangeable tips, solenoid valves, manifold, foot-operated switches, and all necessary tubing and connectors. The System requires a 115-v 60-cycle power. Connection shielded leads permitting electrical testing can be furnished as an accessory.

Carman Laboratories

Circle 58 on postcard for more data

continued on next page

This can't be FIREBAN...

New Taylor FIREBAN 321 Laminated Plastic is self-extinguishing in only 3 seconds

Electrical faults in appliances, TV sets, radios, motors and other electrical devices frequently lead to fires—and these fires lead to complete destruction of the equipment, sometimes extensive damage to the facilities surrounding it. Taylor FIREBAN 321 is designed to retard fire. Self-extinguishing in only 3 seconds—it is an effective barrier against the spread of flame. In addition, this flame-retardant laminated plastic has excellent moisture resistance, excellent electrical resistance after exposure to high humidity, and good mechanical properties; also offers low dielectric losses. These properties help prevent the electrical faults that lead to fires. Write TAYLOR FIBRE CO., Norristown 50, Pa., for complete details.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

Circle 17 on Inquiry Card, page 83

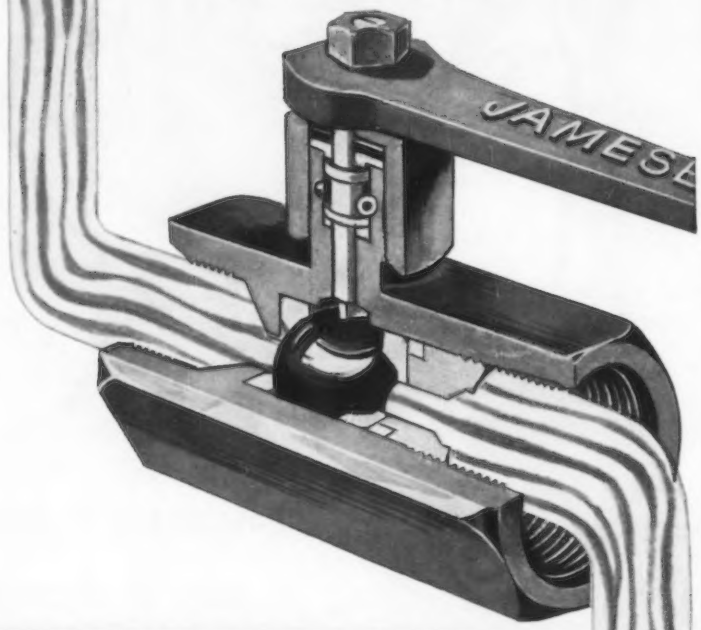
Now, at your service

jamesbury

"Double-Seal"™

HIGH-PRESSURE BALL VALVES
STYLE H SERIES

3000 — 4,500 p.s.i. Range



. . . outstanding design newly available to industry

for
- High-Pressure service
- High-Vacuum service
- Handling of hazardous fluids
- Cryogenic operations

. . . no other valve has these outstanding features

- Unit-body construction
- Positively leakproof
- Full-flow capacity
- Indestructible in service
- Corrosion-resistant
- Contamination-proof
- Incomparable size-rating-test-burst performance ratio

— a newly developed and advanced valve design with broad industrial applications, available in eight sizes — from ¼" through 2" tubing or pipe threads — with 303 and 316 Stainless Steel or Carbon Steel bodies. Choice of nylon or "Teflon" seats and seals.

Distributors in principal cities.
For further information, write: Data: Style "H" Series

225-8

JAMESBURY CORP., NEW STREET, WORCESTER, MASS.

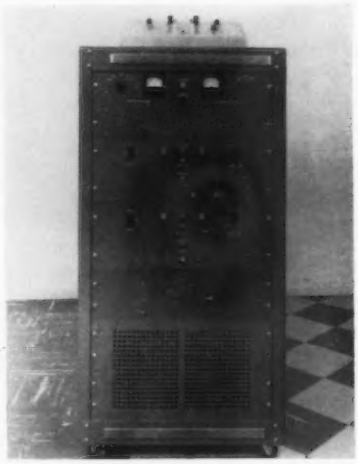
Circle 18 on Inquiry Card, page 83

LOW COST AUTOMATION FOR MACHINE TOOLS

Machine tool automation records complicated, continuous path machine tool movements directly on magnetic tape—without usual expensive computer programming equipment.

This control system provides a simplified, comparatively low-cost method of recording and playback which can be afforded by even the smaller machine shops.

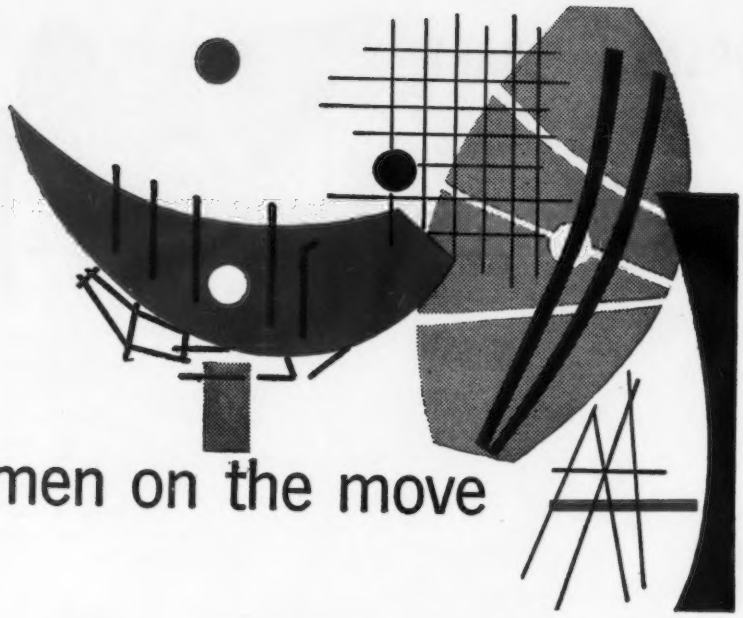
The basic system can be applied to almost any existing machine tool; can also be used in a wide variety of other control applications. It maintains complete three-axis motion control necessary for continuous path work.



Main console shown above houses electronic and tape-handling equipment. Tape deck is accessible from the rear for ease of loading and is fully visible through a transparent cover. Electronic system is modular designed for rollout accessibility.

Micro-Path Inc.

Circle 57 on postcard for more data



men on the move

Levin P. Handy
Robertshaw-Fulton

Raymond C. Blaylock
Chance Vought

LEVIN P. HANDY appointed director of the cable unit, Aeronautical and Instrument Div., Robertshaw-Fulton Controls Co.

RAYMOND C. BLAYLOCK, vice-president-engineering, and GIFFORD K. JOHNSON, vice-president-production, elected to the board of directors of Chance Vought Aircraft, Inc.

C. ROBERT GATES, elevated to director of product planning for the Northrop Div., Northrop Aircraft.

JOHN M. PEARCE fills the new post of manager of electronics requirements at The Martin Co.

JOSEPH M. TILL, named production control manager for the Montebello plant of Western Design, a Div. of U. S. Industries Inc. EDWARD W. VERNON joined the Engineering Sales Staff of Western Design.

RICHARD S. BOUTELLE, elected vice chairman of the Fairchild Engine & Airplane Corp. board of directors. J. NELSON KELLY has joined Fairchild as a customer relations representative.

JAMES M. STONE, named assistant general manager, Des Moines Div., Solar Aircraft Co.

RICHARD A. CARPENTER, named manager of Callery Chemical Co.'s new Washington, D. C. office.

John M. Pearce
The Martin Co.

Joseph M. Till
Western Design

James M. Stone
Des Moines Div.
Solar Aircraft

Richard A. Carpenter
Callery Chemical Co.

R. E. HONER, named assistant chief engineer-electronics for the convair (San Diego) Div., General Dynamics Corp.

EWIN E. GORIN has been designated senior west coasts representative, Bell Aircraft Corp. He will also represent the company's Avionics Div.

FRANK R. HERUD will represent Rockets.

JEROME C. GREGOIRE will represent the Space Flight and Missiles Div.

RUSSELL S. KENERSON, elected president of Thompson Products, Ltd., a subsidiary of Thompson Ramo Wooldridge Inc.

FRED HALL, appointed director of management control for Aerojet-General's Solid Rocket Plant in Sacramento. GORDON BANERIAN, manager of the Turbo-Machinery Div., will serve as Chairman of the National Aeronautics and Space Administration's Research Advisory Committee on Mechanical Power Plant Systems. DR. A. L. ANTONIO, has returned to the Corporation as Vice President-Chemical Div.

SAMUEL J. DAVY, named manager of field operations, Arma Div., American Bosch Arma Corp. KARL H. KELLER, named site manager of Cape Canaveral operation.

HAROLD J. HUBER, appointed section manager, Government and Industrial Staff of the Research Div., Philco Corp. MURRAY HOFFMAN, named group supervisor.

VICE ADMIRAL CHARLES B. MOMSEN, (RET.), named consultant on the staff of the vice president in charge of engineering, Bendix Aviation Corp.

FRANK HERRON has been named department head of scientific programming and analysis, Temco Aircraft Corp.

FLOYD E. KELLEY was promoted to department head of digital computing.

DONALD J. LEMAN, appointed manager - systems and procedures, Consolidated Electrodynamics Corp.

ALBERT P. GAGNEBIN, elected vice president, International Nickel Co. JOSEPH M. WELDON, elected assistant vice president.

J. M. NORRIS, named factory manager, Marquardt's ramjet manufacturing facility, Ogden, Utah.

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● This technician is with Sikorsky Aircraft, Division of United Aircraft Corporation at Stratford, Connecticut. He is placing a 12½" diameter LAMINUM shim on an input assembly. In foreground are other LAMINUM shims. Notwithstanding extremely close assembly tolerances, Sikorsky saves time and cuts costs by using Laminum. No need for micrometer checking, no need for standby grinding or machining. Laminum Shims simply p-e-e-l for a thousandth fit, right at the job. That's why a long list of aircraft as well as missile and rocket producers benefit from the use of laminated shims of LAMINUM.

LAMINUM®
the solid Shim that p-e-e-l-s for adjustment

Laminum looks, acts like solid metal—yet quickly p-e-e-l-s to precision fit right at the job. In Brass, Mild Steel, Type 302 Stainless with .003" or .002" laminations. In Aluminum with .003" laminations or NEW with .002" laminations. Custom-made, Laminum Shims eliminate extra operations: no machining, no grinding, no stacking, no miking. *And no grit between layers—ever!*

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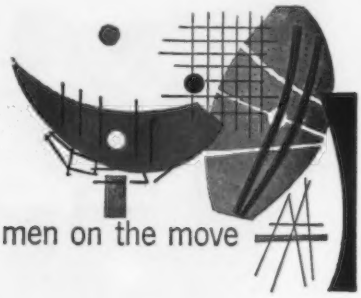
Circle 19 on Inquiry Card, page 83



CHARLES R. ALLEN, joined the staff of D. K. MacLennan Co. of Los Angeles, as technical representative for Misco Precision Casting Co. and Casting Engineers Inc.

THOMAS D. BURLEY, named manager of high temperature steel sales for The Carpenter Steel Co.

Francis S. Napoli
Dumont Aviation Associates

Frank B. Gray
Nuclear Div.
Kaman Aircraft

FRANCIS S. NAPOLI, appointed vice president of manufacturing, Dumont Aviation Associates and appointed general manager, Du-Air Screw Corp.

FRANK B. GRAY, JR., appointed to senior research staff, Albuquerque Nuclear Div., Kaman Aircraft Corp.

G. N. ROSWELL, named secretary, Leach Corp.

DUNSTAN GRAHAM, appointed head of the newly-instituted Systems Management Office of Lear, Inc., Astronics Div.

GEORGE C. FAITH, appointed sales manager, Solrac, Inc.

Dunstan Graham
Lear Inc.

George C. Faith
Solrac

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Converter Camera

Details on ultra-high speed image converter camera.

Librascope Inc.
Precision Technology Dept.
Circle 62 on postcard for more data

Space Age Lathe

"Missile Master" lathe for missile components described completely, with specifications, additional equipment.

Monarch Machine Tool Co.
Circle 80 on postcard for more data

Convair Research

Report gives personnel, facilities of Scientific Research Department, Scientific Research Lab, Manufacturing Div's contracted research, and Scientific Consultants Board.

Convair
Div. of the General Dynamics Corp.
Circle 89 on postcard for more data

Cobalt

New data sheet on metal cobalt includes general properties, facts on 99.6 per cent pure cobalt.

Cobalt Information Center
Battelle Memorial Institute
Circle 66 on postcard for more data

Word Indicator Light

Brochure gives features, design diagrams of rotating word indicator light which can be rebulbed from front, without tools.

Master Specialties Co.
Circle 81 on postcard for more data

Material Guide

Material Guide for over 325 different temperature measuring applications.

Thermo Electric Co.
Circle 79 on postcard for more data

Fluid Facts

First of a regular series of valve application data sheets.

Koehler Aircraft Products Co.
Circle 72 on postcard for more data

Gears

High-performance, precision gears from less than one inch to over 200 inches in diam. and with tooth-to-tooth spacing accuracies of two ten-thousandths of an inch described in bulletin GEA-6430.

General Electric Co.
Circle 77 on postcard for more data

Tantalum

New four-page technical folder describes application of NRC high-purity tantalum to the electronic, nuclear, chemical and missile industries.

National Research Corp.
Circle 90 on postcard for more data

Components—Facilities

Four-page 2-color brochure on firm's line of precision components for computers, instruments and control systems. Eight page brochure on abilities and facilities in missile system development and precision production.

Ford Instrument Co.
Circle 67 on postcard for more data

Ground Current Conduction

Article explains importance of ground current conduction pertaining to welding positioners.

Aronson Machine Co.
Circle 68 on postcard for more data

1959 Outlook

Official 1959 outlook for the machine tool industry.

Metalworking Equipment Division
Business and Defense Services Administration
Circle 84 on postcard for more data

Alcoa Plants

Thirty-six page booklet discusses equipment, products, and services of plants producing aluminum and magnesium forgings.

Aluminum Co. of America
Circle 85 on postcard for more data

Hypervelocity Cameras

Rotating mirror camera and rotating drum camera for hypervelocity recording are described.

Avco Research and Advanced Development Div.
Circle 63 on postcard for more data

Singer Facilities

Facilities for service to the Armed Forces and their prime contractors are described in a new four-color booklet.

Military Products Div.
Singer Mfg. Co.
Circle 71 on postcard for more data

Ground Pressure Fueling

Thirty page publication on aircraft ground pressure fueling systems and components.

Parker Aircraft Co.
Circle 75 on postcard for more data

Jewel Bearings

Comprehensive manual on jewel bearings and other industrial applications of sapphire.

A. M. Gatti, Inc.
Circle 61 on postcard for more data

Precision Surface Equipment

Catalog No. 839 describing 300 standard items of Challenge Precision Surface Equipment.

Challenge Machinery Co.
Circle 70 on postcard for more data

Auxiliary Power Unit

Design, operating features of AM-10 self-contained electric-hydraulic power-generating unit for missile and aircraft accessory power.

General Electric
Circle 91 on postcard for more data

Catalog Folder

Short form shows firm's electronic components and instruments.

Burroughs Corp.
Electronic Tube Div.
Circle 74 on postcard for more data

worth asking for:

technical literature listed here is available without charge from the various manufacturers

Regulators

Bulletins on small volume high pressure regulators, powreactor dome regulators.

Grove Valve and Regulator Co.

Circle 87 on postcard for more data

Wall Chart

Welding shop wall chart of 89 specialty alloys and fluxes.

All-State Welding Alloys Co.

Circle 65 on postcard for more data

Glossary

Pocket-size glossary of astronautical terms.

Republic Aviation Corp.

Circle 78 on postcard for more data

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FILTERED RESTRICTORS

No rubber required except in end fittings.
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Low pressure drop.

SHUTTLE VALVES

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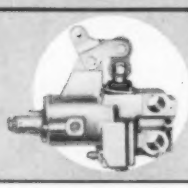
SERVO VALVES • ACCUMULATORS
PRESSURE REGULATORS



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For Special Applications.

ALL HYDRAULIC UNITS FUNCTIONAL TESTED

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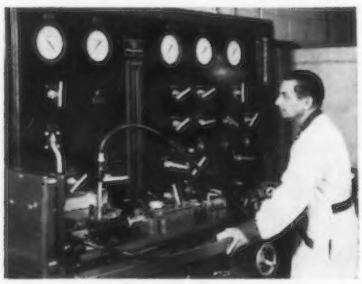
Quality Control procedures per MIL-Q-5923-C

CERTIFICATIONS FURNISHED



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Your inquiry will receive immediate reply from engineers experienced in precision hydraulics.

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Laminated Plastics

Silent gears made from laminated plastics described in reprint.

Taylor Fibre Co.

Circle 86 on postcard for more data

Catalog & Glossary

Electro-mechanical catalog features drawings, performance curves, design data, on over 120 motors, linear actuators, solenoids, other equipment. Also available; electro-mechanical actuator glossary.

Hoover Electric Co.

Circle 64 on postcard for more data

Markings

New products bulletin describes characteristics and specifications for a new "Duralar" plastic laminate for markings.

Duralith Corp.

Circle 82 on postcard for more data

Bearings

Design details on line of pillow block and flange bearings.

Hoover Ball & Bearing Co.

Circle 60 on postcard for more data

Gearmotor

Bulletin describes positioning gearmotor for punch card machine toll positioning and programming.

Jordan Co.

Circle 76 on postcard for more data

Control Displays

Booklet contains descriptive information, free samples, and instructions on how to use special, plastic laminated pictorials of standard controls and displays.

Michelson Peters Control Displays

Circle 69 on postcard for more data

Remote Control

New devices for remotely handling radioactive, toxic or highly flammable materials.

Mechanical Div. General Mills, Inc.

Circle 88 on postcard for more data

Takeoff Monitor

Eight-page booklet describes new takeoff monitor system.

Aeronautical Div.
Minneapolis-Honeywell Regulator Co.

Circle 83 on postcard for more data

Filters

A 132-page, 8½ by 11-in, two-color filter engineering and application reference manual offered.

Bendix Filter Div.
Bendix Aviation Corp.

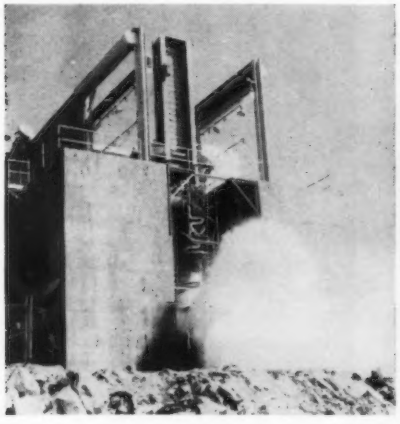
Circle 73 on postcard for more data

industry notes

X-15 EXPECTATIONS

First of three X-15 research vehicles shown on rollout from Los Angeles Div. of North American Aviation. Wedge-shape was chosen for effectiveness at high speeds. Note side fairing for equipment, aerodynamic purposes. In emergency, installed cockpit could become escape capsule. X-15 s 50 ft long, weighs about 32,000 lb, spans 22 ft.

X-15's liquid propellant, 60,000-lb-thrust rocket engine is tested at Denville, N. J., where it was produced by Reaction Motors Div. of Thiokol Chemical.



Vice president Richard Nixon and North American Board Chairman J. H. Kindelberger (right) examine plane's tail, much of which is movable for control.

The X-15 manned satellite test bed, newest of a series of rocket-powered research aircraft, is making its initial aerodynamic sorties this month.

First test-flights take place against this background:

◆ North American Aviation produced the plane in its Los Angeles Div. for the Air Force, Navy and NASA. It is slated to be the first manned space-craft; designed to reach up to 3600 mph in a ballistic trajectory following a 90 second rocket-impelled shot upward.

◆ Unique design and new manufacturing techniques make the X-15 an important research craft for future applications.

◆ Top defense officials said in 1954 that the project

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22,000 hours a
week of superior
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are applied to
the design
of advanced
military
electronics

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Circle 21 on Inquiry Card, page 83

industry notes

X-15 . . . continued

Space suit made by David Clark Co. is aluminized to help protect pilot from re-entry heat. Inside protective helmet, pilot breathes pure oxygen.

North American test pilot Scott Crossfield will take the X-15 through initial evaluation flights before it goes to Air Force and NASA pilots.

was "a matter of national urgency." Impending flight beyond the atmosphere makes imperative an investigation of aerodynamic heating, stability, control, and physiological factors, including weightlessness.

◆ A wide portion of U. S. industry has contributed know-how towards solving a new generation of problems. More than 300 firms are involved. Entire program has cost an estimated $120 million, the Air Force supplying the largest portion of funds.

Tests this month, preliminary drops from B-52, will check out calculated aerodynamic factors. If performance does not measure completely with calculations, plane may be changed somewhat. Likewise, reconsideration of physiological factors may be necessary in Navy's centrifuge at Johnsville, Pa.

After exhaustive powered and unpowered tests, below peak altitude, by North American, X-15 will be turned over to the Air Force and NASA. Final mile-per-second thrust culminates all the ground and air testing. This momentous flight is expected in late 1959 or early 1960.

After air-launching from the B-52's attachment pod, the X-15 will be capable of accelerating above Mach 5. Advanced design liquid propellant rocket

NEXT MONTH
Look for the Missile Handbook!

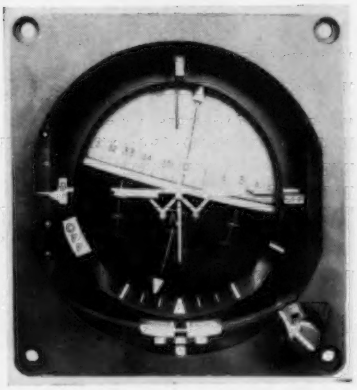
engine developed by Reaction Motors is capable of producing more than 60,000 lb thrust. (Lox and liquid ammonia propellants flow at over 10,000 lb per minute.)

As it accelerates to hypersonic speed, coasts silently in its ballistic arc, and re-enters the denser atmosphere, the plane will collect data on pressure, heat, control, aeromedical problems from some 1300 lb of instrumentation. Four ground stations along the Wendover, Utah to Edwards Air Force Base flight path will record plane and pilot performance.

Among the design factors under scrutiny: wedge fins of 12 inch trailing edge thickness; anhedral tail.

At least 65 per cent welded structure, the plane is designed to stand high aerodynamic loads and buffeting. North American used both automatic fusion welding and resistance welding to form an ultra-strong weld as good as the parent material.

If the re-entry were at top speed, body temperature might approach 1200°F at leading edges. Protective Inconel X nickel alloy was supplied by International Nickel Co. North American used special techniques to form it. Titanium and stainless steel inside this armor likewise called for special forming techniques.



Modified version of three-axis "Astra" Indicator will provide pilot with attitude reference in respect to earth. Indicator was built by Grand Rapids Div., Lear Inc.

During the flight, altitude, velocity, attitude, and rate-of-climb information will be provided by a short-time-of-flight inertial system developed by Sperry Gyroscope Co. System includes four-gimbal, three-gyro-stabilized platform, associated computers, and three cockpit indicators. Three accelerometers, mounted on the platform, record changes in velocity in any direction.

Liquid nitrogen, contained at about —300°F, will be used as cooling agent. Produced by the AiResearch Manufacturing Div. of the Garrett Corp., it will pressurize and ventilate cockpit and pilot's flight suit. The X-15 will go to heights where conventional pressure systems cannot operate. Therefore, it must carry its own atmosphere.

Pressurized helium gas contained in a spherical chamber at 4,000 psi pressure, will expel the nitrogen in liquid or spray form.

Most important component in the flight is, naturally,

Fabric-laminated-thread B. F. Goodrich tires on the dual nose wheels will be utilized in subsonic landing. Steel shoes on short struts pop from aft fuselage section to help cushion landing.

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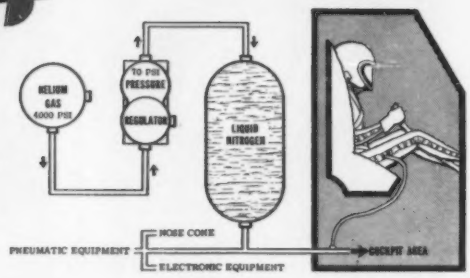
X-15 . . . continued



X-15 will carry its own atmosphere, because high-altitude air is too rarified for pressurizing. Liquid nitrogen system produced by AiResearch Manufacturing Div. of The Garrett Corp. supplies pressure.

the pilot, a "human servo" whose split-second decisions could make a vital difference in the X-15 performance. Hence, the extensive tests under simulated g-loads at the Navy's centrifuge. Right-hand stick is used under high load factor in the atmosphere during boost and re-entry. It can be controlled by wrist movement under high g's.

With his left hand, pilot can actuate small rocket engines in wing tips and nose of his plane. These Bell Aircraft products use hydrogen peroxide and a catalyst as the propellant. Nose rockets will control pitch and yaw movement. Wing-tip rocket will effect roll control.

The swift, red-hot, re-entry may call upon pilot for most important control decisions. In centrifuge tests, involuntary pilot inputs under off-flight-path oscillations were found dangerous, though not prohibitive. Under simulated damper-control failure, every test pilot blacked out as plane went through violent motions. The Sperry flight instrument system's principal function is helping pilot control plane in re-entry. Aim is to prevent too steep a re-entry or "bouncing back" too high from a shallow trajectory.

Before landing, bottom half of lower vertical tail is jettisoned. Air brakes are fitted on either side of the fin trailing edges, near the fuselage. Landing gear on the X-15 consists of two steel skids and dual nose wheels. Landing speed is about that of the F-104 Starfighter. Entire trip is expected to last about 20 minutes.

NEXT MONTH
Look for the Missile Handbook!

X-15 PAINT
made to resist
+1200° F
The world's first rocket space ship, designed to carry man into the ionosphere, is painted with a Rinshed-Mason heat-resistant black enamel. This super tough finish was made expressly for North American Aviation, Los Angeles Division, manufacturers of the X-15. Aerodynamic temperature build-up to +1200°F. is expected as this "black phantom" reaches the re-entry phase into the earth's atmosphere at hypersonic speeds. The R-M enamel is expected to withstand these extreme temperatures and to dispel the absorbed heat at the fastest possible rate.
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CONTRACTS

Navy picked MCDONNELL'S F4H-1 as its all weather fighter. Scheduled for operational use early next year, F4H-1 carries radar operator besides pilot, is piloted by two J-79 turbojet engines. Navy dropped contracts totaling $100-million for CHANCE VOUGHT'S CRUSADER III, which had been in competitive flight tests with the McDonnell craft.

To FAIRCHILD ENGINE AND AIRPLANE CORP.'S APPLIED SCIENCE DIV., contract estimated at $102,000 to obtain performance characteristics of air vehicles expected to operate in civil-military system of air traffic control, from Federal Aviation Agency Bureau of Research and Development.

To HOFFMAN LABORATORIES DIV., HOFFMAN ELECTRONICS CORP., $1,500,000 Navy Bureau of Aeronautics contract for several thousand SSQ-23 "Sonobuoy" anti-submarine devices. Dropped from submarine hunter aircraft, Sonobuoy floats, relays back information on underwater sounds.

To PUROLATOR PRODUCTS INC., $284,000 in Air Force contracts for filter replacement elements used with refueler trucks filtering aviation gasoline and jet fuels; or used to remove contaminants and water from jet fuel.

To VERTOL AIRCRAFT CORP., $2,044,345 contract for six 44A helicopters and associated equipment from the Air Force.

To the NUCLEAR PRODUCTS-ERCO DIV., ACF INDUSTRIES INC., Navy contract to produce electronic flight simulator for the Grumman-built S2F-3 anti-submarine plane.

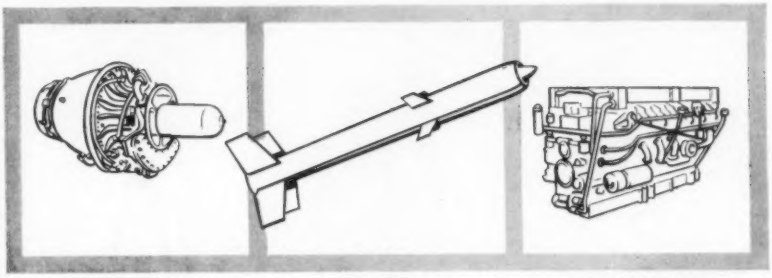
To PERMANENT FILTER CORP., Los Angeles, Air Force contract to produce its Perma-Dry water separation and filtering units for combating jet aircraft fuel icing problem by separating water from the jet fuel.

To THE MARTIN CO., Orlando, Fla., $54-million contract for continued research and development on Pershing weapon system: from Army. Contract marks a departure from Army "arsenal concept"; since Martin has prime contractor responsibility instead of the Army. Also, a $23-million Navy contract to MARTIN'S BALTIMORE DIV. for production of P5M-2 anti-submarine warfare seaplanes with new sub detection system.

continued on next page

NEXT MONTH
Look for the Missile Handbook!

CAE
POWER
• Research
• Development
• Production



TURBINE RAMJET RECIPROCATING

● Continental Aviation & Engineering Corp. is exceptionally well qualified, both by experience and by facilities, for work on the weapons systems of tomorrow. Our background embraces not only a half-century of internal combustion engine experience, but also years of pioneering in gas turbine engine development, and a full decade of work in the field of solid fuels for ramjet propulsion of missiles and target drones . . . Continental is staffed and equipped for a wide range of assignments, military and commercial. The Detroit Division Research and Development Department is supported by our modern-to-the-minute Component Testing Laboratory complete with environmental facilities located at Toledo. The Toledo Production Division now producing various turbine engines in volume is capable of supporting diversified programs . . . The CAE record of achievement is one of which many a larger company might be proud. Inquiries are invited from those having propulsion problems, on the ground, on the water, in the air.

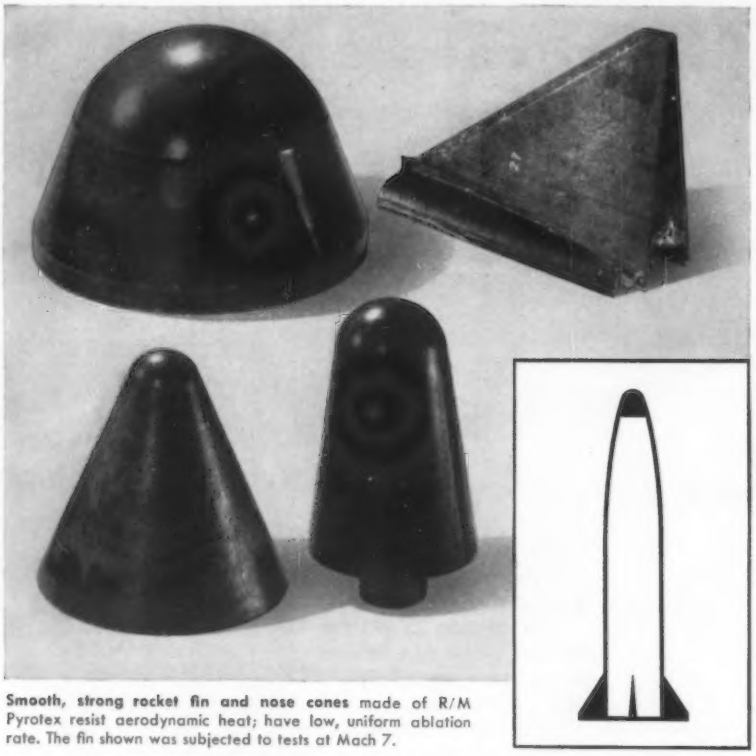
☆ ☆ ☆

CONTINENTAL AVIATION & ENGINEERING CORPORATION
12700 KERCHEVAL AVENUE, DETROIT 15, MICHIGAN
SUBSIDIARY OF CONTINENTAL MOTORS CORPORATION

 Circle 23 on Inquiry Card, page 83

R/M PYROTEX® REINFORCED PLASTICS ...DEVELOPED TO ENDURE THE FIERY REALM OF THE ROCKET

Light, strong, heat resistant . . . for low-cost, precision fabricated rocket parts— both structural and aerodynamic



Smooth, strong rocket fin and nose cones made of R/M Pyrotex resist aerodynamic heat; have low, uniform ablation rate. The fin shown was subjected to tests at Mach 7.

Looking for a material that will withstand the elevated temperatures generated by missiles and rockets—internally from burning propellants, externally from aerodynamic heating? Must this material have good insulation and thermal properties, chemical and water resistance, and take a smooth finish? If so, one of R/M's family of Pyrotex reinforced plastics may be the solution to your problem.

The many outstanding thermal and structural features of R/M Pyrotex have led to its use on almost every U.S. missile. It has been fabricated into parts such as nose cones, fins, igniter tubes, rocket throats and silver traps. Its exceptionally good dimensional stability makes possible mass production to precision standards. And it is low in cost. Write for additional information.

RM

RAYBESTOS-MANHATTAN, INC.

REINFORCED PLASTICS DEPARTMENT, Manheim, Pa.

FACTORIES: Manheim, Pa.; Bridgeport, Conn.; Paramount, Calif.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Asbestos Textiles • Laundry Pads and Covers • Engineered Plastics • Mechanical Packings • Sintered Metal Products • Industrial Rubber • Rubber Covered Equipment • Brake Linings Brake Blocks • Abrasive and Diamond Wheels • Clutch Facings • Industrial Adhesives • Bowling Balls

industry notes

CONTRACTS . . . continued

Air Force has trimmed its plans for procurement of CONVAIR'S B-58 HUSTLERS this fiscal year. Letter contract calls for 36, instead of 47, new Hustlers in addition to 30 previously ordered.

Air Force stretchout on programs for production of B70 chemical bomber and F-108 long-range interceptor at NORTH AMERICAN AVIATION was reported.

U. S. CHEMICAL MILLING CORP. announced initial major entry into commercial field with receipt of $2-million contract for production of automatic coffee machines at Chemical Milling, Missile Air and Electronics Divisions.

NORTH AMERICAN AVIATION announced the following major design and production responsibility for F-108 interceptor and B-70 bomber programs: CONVAIR DIV., GENERAL DYNAMICS CORP.: F-108 wing; LOCKHEED AIRCRAFT'S GEORGIA DIV.: a fuselage section of B-70 Valkyrie bomber. CHANCE VOUGHT AIRCRAFT: B-70 horizontal and vertical stabilizer sections.

The Eagle, long range air-to-air fleet air defense missile, will be developed and produced by BENDIX AVIATION CORP. GRUMMAN AIRCRAFT ENGINEERING CORP. will develop the airframe.

Navy cancelled its "Rat" anti-submarine weapon program because of "superior" weapons being developed. Program had not reached production contract stage.

To AIRBORNE INSTRUMENT LABORATORIES, Mineola, L.I., contracts totaling $1,786,124 for radar surface detection equipment which will show exact location of aircraft on the ground; to be delivered in about 18 months; from Civil Aeronautics Administration.

To NORTHROP DIV., NORTHROP AIRCRAFT, $50-million Air Force contract for production of additional Snark SM-62 ICBM's, spare parts, ground support equipment, through December 1960.

NEXT MONTH
Look for the Missile Handbook!

MISSILE METALS OUTLOOK: 1959

Outlook for metal production in 1959 based on reports from Business and Defense Services Administration, trade sources:

▸ Columbium — little increase seen unless present experimental use finds wide application.

▸ Aluminum — promising outlook with shipments by producers to consuming industries expected to increase about 20 per cent over 1958. This would give a total production of 1,868,400 tons.

▸ Tantalum—volume of production to equal or exceed '58 production. Limited world reserve of tantalite could create a problem if requirements increase greatly.

▸ Titanium—continued pickup from the low point of late 1957. One factor is continued large shipments to builders of commercial aircraft. Sales for military aircraft rallied in '58 though overall shipments declined. Two new titanium alloys—a heat treatable sheet and an engine material—have been developed for the B-70 bomber and the F-108 fighter. Another alloy, called "all-beta" is being made available as titanium finds increasing use for high strength use in missiles.

▸ Steel—forecasts for the year range anywhere from mill output of 100 million tons to as much as 115 million tons.

SUPERALLOY

Arresting tail hook, subject to exhaust flame temperatures from 600 to 700°F in T2J jet trainer landings, is of special steel alloy called A-286. Made by Allegheny Ludlum Steel Corp., alloy retains high strength up to 1300°F under high stress.

ELECTRO-MECHANICAL ELECTRONIC ENGINEERS

A BS or advanced degrees in EE, ME, or Physics, may qualify you for a career at NAA, home of the advanced B-70, F-108, and X-15.

Flight Control Analysis, Reliability Analysis, Flight Simulation, Systems Analysis.

Electrical Systems Analysis and Design, Mission and Traffic Control, Fire Control, Bombing Systems, Electronics Systems Integration, Flight Controls, Ground Support Equipment, Airborne and Electronic Test Equipment.

Applied Research in Radome Development, Antenna Development, Infrared, and Acoustics.

Please write to: Mr. L. B. Stevenson, Engineering Personnel, North American Aviation, Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.

Circle 25 on Inquiry Card, page 83

OSBORN®

BEFORE BRUSHING
Jet engine part formerly hand-filed and emery-rubbed to remove burrs and sharp edges. Hand-finishing time: 80 minutes.

AFTER BRUSHING
Burrs are thoroughly removed, edges and surface junctures are blended to radius tolerances . . . each part is precision-finished quickly, uniformly. Osborn Brushamatic® finishing time: 8 minutes.

Flying finish for jet engine parts

. . . 10 times as fast with precision OSBORN Brushamatic® Methods

JET ENGINE COMPONENTS *are precision finished automatically at high production rates on Osborn Brushamatic® 51-OOL Machine.*

HERE'S how a jet engine manufacturer has broken a production bottleneck . . . saved dollars and days in the precision-finishing of jet engine components . . . with Osborn Brushamatic® Methods.

Sharp edges, burrs or scratches on components cause stress concentrations and resulting fractures—so a high degree of surface refinement is essential. *Tedious hand finishing each of these parts used to take 80 minutes.* Still, job quality was inconsistent . . . costly in time and money.

Today, Osborn Brushamatic does the same job in 8 minutes . . . 10 times as fast . . . with a high-quality, uniform finish held to microinch specifications.

It's typical of how Osborn Power Brushing works to help *you* speed production . . . cut costs . . . improve product quality. Write for details. *The Osborn Manufacturing Company, Dept. AM-2, Cleveland 14, Ohio.*

Osborn Brushes

BRUSHING MACHINES • BRUSHING METHODS
INDUSTRIAL BRUSHES • FOUNDRY PRODUCTION MACHINERY

industry notes

LUNIK SPURS U. S. EFFORTS

Among the programs vieing with "Lunik" the Russian solar satellite:

- More U. S. moon shots are imminent.
- Instrumented rockets are expected to be launched towards Mars in August.
- Rocketdyne Div. of North American Aviation is developing a million-pound-thrust liquid propellant rocket engine.
- Convair Div. of General Dynamics Corp. is developing a special version of an Atlas upper stage missile for space exploration; Pratt and Whitney developing the engine.

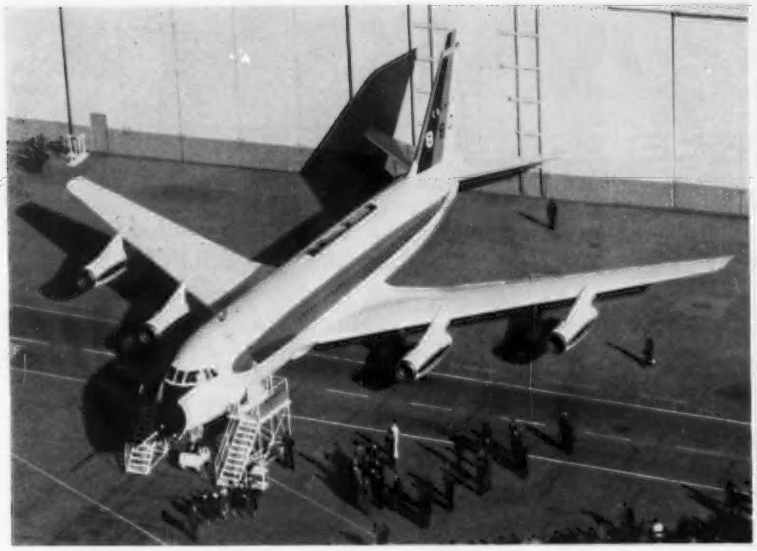
Reportedly boosted by over 500,000-pound-thrust rocket, Lunik passed within 5,000 miles of the moon, is in its first 15 month solar orbit on a path between 91.5 million miles and 214.75 million miles from the sun.

MOLYBDENUM MILESTONE

First casting of molybdenum (by Bureau of Mines scientists) is a new manufacturing method of obtaining irregular shapes from the high-temperature-resistant metal.

Previous methods—molding from powder or making ingots for machining—permitted production of only limited shapes from molybdenum.

Metallurgists at the Bureau's Albany, Ore. laboratory obtained the casting by melting the metal with a high-density electric arc in a water-cooled, copper-lined crucible under inert atmosphere.



880 FLIGHT TESTING BEGINS

Convair's medium-range swept-wing 880 jet airliner, its gold stripes suggesting money in the clouds, is making its initial flights as newest entrant in the commercial airline sweepstakes.

The 615 mph jet rolled from the San Diego plant of the Convair Div. December 15; then went into its exhaustive 16 month ground and flight testing program.

Maiden flight, scheduled this month, begins the flight test phase. Cabins of the first three 880's to fly will carry ballast tanks and instrumentation. Fourth 880 will be equipped with complete passenger cabin.

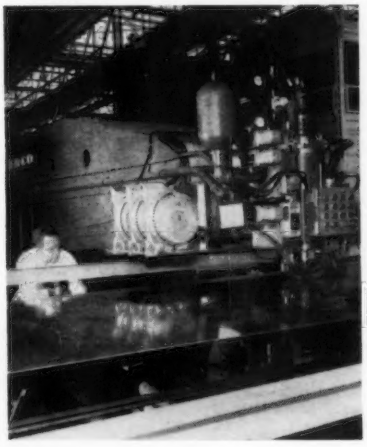
First delivery of 30 ordered by TWA is scheduled for this October. Other orders are from Delta, (January, 1960); Swissair, (October, 1960); REAL-Aerovias of Brazil; Transcontinental of Argentina. American Airlines has ordered 25 Convair 600's (sister ship of the 880).

The basic 800 was designed for flights ranging from 300 miles to transcontinental distances of 3,450 statute miles. Intercontinental version has fuel capacity for 4,210 statute miles. Capacity is 88 passengers (110 when four-abreast arrangement is converted to five-across standard seating).

Plane's four General Electric CJ-805-3 jet engines, each delivering 11,200 lb static thrust, are commercial versions of the military J-79 powering Convair's B-58 bomber.

Thick fuselage and wing skins are part of the extra beef which Convair designed into the plane.

Giant 21-ton riveting machines drill holes, insert rivets in wing and fuselage panels of 880 and 600 jetliners at rate of one rivet every three and a half seconds.



ELECTRONICS ENGINEERS

Work on America's most advanced weapon systems

At North American Aviation, work on such top-level projects as the B-70 and F-108 weapon systems, and the X-15 manned space ship, has created unique careers with a tremendous engineering potential. Widen your horizons in these fields: Flight Control Analysis, Reliability Analysis, Flight Simulation, and Systems Analysis.

We have immediate openings in applied research on radome development, antenna development, infrared, and acoustics.

Minimum requirements are actual experience plus B.S. and advanced degrees in E.E. and Physics.

For more information please write to: Mr. L. B. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.

Circle 27 on Inquiry Card, page 83

BARCO

FLEXIBLE HYDRAULIC ASSEMBLIES FOR MISSILE LAUNCHERS

—Approved Designs! Dependable Performance!

For maximum speed in development work, it pays to eliminate every "unknown" possible! The performance of Barco products is a KNOWN QUANTITY. Barco Swivel Joints and Flexible Hydraulic Assemblies are of approved design. Their performance has been proved by thousands of hours of dependable service on active military installations, including *Nike* batteries of both original and latest improved *"Hercules"* type. This wide experience is yours to call upon in the development of your particular project. Our engineers will be glad to work with you on special problems and assist with recommendations. Ask for Catalog 269-A.

Flexible Joints for Handling LOX and Other Rocket Fuels

Barco has the *specially designed* Ball Joint which has passed the official *"Qualification Test"*. Barco joints are used to provide *flexibility* in metal loading lines handling liquid oxygen, white fuming and red fuming nitric acid, JP 3, 4, and 5, and other high energy fuels. Sizes 2", 3", 4", 6", and larger. ASK FOR NEW BULLETIN 233A.

BARCO MANUFACTURING CO., *Serving Industry Since 1908* **565C Hough St., Barrington, Ill.** AIRCRAFT DIVISION

Circle 28 on Inquiry Card, page 83

industry notes

SCRAP PROBLEMS CAN BE SOLVED

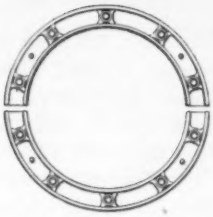
Material scrap, weighed in dollars, can add up to a considerable sum of money.

Example of the problem occurred at Wright Aeronautical Div. of Curtiss-Wright Corp., Wood-Ridge, N. J. The firm was making heat resistant N-155 alloy connector rings from flat stock. Rings, used in segmented nozzles which collect hot exhaust gas from engine cylinders, had to be rolled, clamped and welded in 15-inch lengths. One inch of each piece was scrapped to remove build-ups and burns due to starting and stopping the weld at each end. Waste amounted to thousands of dollars each year.

Wright Aeronautical's solution: 20-ft lengths of welded N-155 alloy tubing. Production procedure was reduced to cutting off the proper length rings with a wet wheel and deburring.

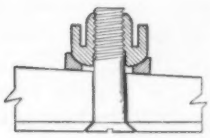
Metal chips from fabrication of wing skins and spars of the Boeing B-52G Stratofortress are collected in sluice and deposited into trough in this underground tunnel. Washed to central collection building, chips are crushed for sale.

How ESNA® solves 7 typical aircraft fastening problems



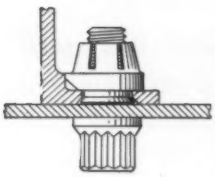
Speedier installation of access panels

ESNA gang channel nut strips eliminate the costly, time consuming installation job of riveting individual nuts. Available in straight or curved sections and even complete rings, custom designed for applications such as access doors or inspection covers.



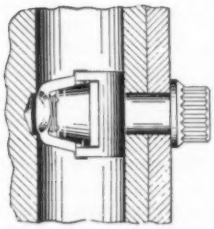
Bolting non-parallel surfaces

No more costly spot facing, step milling or hand selecting tapered shims! ESNA's counterbored, self-aligning types include one lug, two lug, gang channel, standard hex and high tensile types. Ball-and-socket relationship of nut and special base allow an 8° tilt in any direction from centerline to compensate for draft angle or tapered sections.



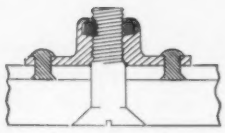
Fastening stressed joints subject to temperatures up to 1300°F.

For really "hot" applications such as jet engine flange assemblies or fire wall sections, where fastener dependability is critical, ESNA offers the "long-beam" locking device. The full cantilever of these sections assures protection against failures related to relaxation, creep and similar problems caused by the effects of extremely high temperatures upon metals. **(Ask for ESNA Bulletin No. 5715 Design Manual for High Temperature Self-Locking Nuts.)**



Simplifying major substructure joining

An ESNA barrel nut doesn't have to be held for wrenching . . . doesn't need precisely mated bolt holes. The barrel-shaped fastener is simply finger-pressed into a drilled or reamed hole until the special clip snaps into position at the bolt hole location. The .030" float of the nut section of this fitting avoids misalignment problems and the bathtub recess for wrenching area is eliminated. New NAS 577 barrel nut (180,000 psi) now available. Also 160,000 and new 220,000 psi series.

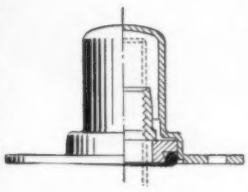


Applications requiring guaranteed high reusability through more than 50 on-off cycles.

Where repeated tear-down and re-assembly or frequent readjustment is required, the exceptional elastic "memory" and non-galling characteristics of ESNA's standard nylon locking insert guarantees long lasting locking torque and fastening dependability. Available in all sizes and configurations of standard aircraft type nuts. Parts can also be designed to order and in any standard configuration, with guaranteed re-use factors as high as 300 on-off cycles.

Attaching components in areas with limited wrench clearance.

Miniaturized insert-type hex nuts with across-the-flats dimensions as small as .109 in the 0-80 size . . . or all metal (550°F.) nuts to AN365 or NAS 679 performance specifications with internal wrenching hexagon faces (which permit use of smaller wrench sizes) are available for use at locations where space and weight limitations are paramount. Complete lines of NAS miniature anchor nuts in carbon steel and A286 stainless steel are also in production. **Ask for your copy of the NAS/ESNA Conversion Book.**



Sealing against fuel tank leakage

No danger of highly volatile fluids leaking past bolt threads with ESNA's self-sealing, floating anchor cap nut! The one piece cap unit is provided with "O"-ring seal around its base *which seals immediately the nut is riveted to the surface.* The self-locking nut enclosed within the cap has .025" float to compensate for misalignment. Also available in gang channel nut strips.

ELASTIC STOP NUT CORPORATION OF AMERICA

-WHAT ARE YOUR FASTENING PROBLEMS?-

Dept. N49-23, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, N. J.

Please send me details on the following:

- ☐ Installing access panels
- ☐ Sealing against leakage
- ☐ Fitting in limited space
- ☐ Bolting non-parallel surfaces
- ☐ Simplifying substructure joining
- ☐ Assuring high re-usability
- ☐ NAS/ESNA Conversion Book
- ☐ Bulletin No. 5715 High Temperature Design Manual

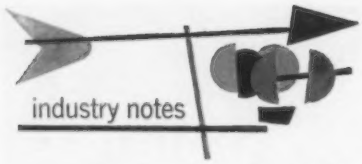
Name_____ Title_____

Firm_____

Street_____

City_____ Zone____ State_____

Circle 45 on Inquiry Card, page 83



TERRA-SCOPE

Emergency spare parts chest containing about 1,500 components has been developed for cargo compartment of Lockheed C-130 Hercules. Lockheed's Spare Parts Department and Warner Robins Air Material Area teamed up for improvement.

•

The Navy plans eight to ten more weather-predicting rockets this year. Rockets include motion picture cameras taking 85-mile-high pictures of cloud formations. Rockets of this type, consisting of Nike-Ajax first stage and Terrier second stage, photographed cloud formations from 200 to 700 miles offshore.

•

Britain claims the fastest, twin-engined all-weather fighter in full production in the world. Basis: Lightning P-1, manufactured by English Electric Co., Ltd., which flew the equivalent of twice the speed of sound at 40,000 ft. over the Irish Sea. Acceleration: from slightly below the speed of sound to twice this speed within four minutes.

The French "Mirage III A" O1 is now at the C. E. V. (Flight Test Center) after regularly reaching Mach 2 speeds in constructor's tests. Its Nord. 5103 booster rocket allowed it to climb to over 60,000 ft at Mach 1.7.

•

LogBalNet—logistic ballistic network—is regarded as significant speedup in supplying missile spare parts to world bases. As it operates at Rocketdyne's Van Nuys facility, launching site twx's its need to Norton AFB, which relays it to Rocketdyne warehouse. Punched cards are fed here into IBM 705 computer, showing exact outgo and supply level.

•

Super-radar center under construction at Clear, Alaska, will be largest of its type in North America. Part of the new B-MEWS (Ballistic Missile Early Warning System), it may be completed by late 1960; RCA supervising installation.

•

"Talon" has been selected from 5,000 entries as the name for the T-38 jet trainer being produced for the Air Force by Northrop Div., Northrop Aircraft at Hawthorne, Calif.

SELENIUM TR UNIT
shock mounted model 28V100-5

SILICON TR UNIT
convection cooled model 28VS100C

DC-DC CONVERTER
dual output model 75D2D50

STATIC DC-AC INVERTER
high temperature effiency, model 283I50

Why Chatham supplies more aircraft power conversion units than anyone else!

Preference of aircraft designers has made Chatham the world's number one supplier of power conversion equipment for missiles . . . jets . . . airliners. Here's why Chatham holds this position.

Custom manufacture: Chatham tailors each unit to supply top performance under all environmental conditions with minimum size and weight.

Components control: All solid-state components are made right at the Chatham plant. Thus, Chatham power supplies are never limited by "specs" of commercially available components.

AC-DC, DC-DC, DC-AC, silicon, germanium, selenium: Any requirement met. Many Chatham units are immediately available. To meet extraordinary demands, Chatham will design and produce an original unit to any specifications you outline without delay.

When specifying power conversion equipment, think of Chatham first because Chatham is first. For specific data, contact: Chatham Electronics, Division of Tung-Sol Electric Inc., Livingston, New Jersey. Sales Offices: Culver City, Cal., Dallas, Tex.

CHATHAM ELECTRONICS
division of
TUNG-SOL ELECTRIC INC.

CHATHAM—WORLD'S LEADING SUPPLIER OF AIRBORNE CONVERSION EQUIPMENT

TECHNICAL PROSPECT

Electrostrictive ceramic used in driver elements of loudspeakers removes need for heavy magnets or coils, allows lightweight speakers. Developed by Mullenbach Div., Electric Machinery Mfg. Co., ceramics are sophisticated compounds of barium titanate, baked in thin discs and then bonded to larger titanium disc. Possible applications: sonar installations, missile components.

•

Fluorescent plastic film for aircraft markings was announced by Minnesota Mining and Manufacturing Co. Usually pressed in place by hand (except with jets, which also require liquid sealer) film is held by pressure-sensitive adhesive, can be cut to shape.

•

Advancements towards lower cost high-temperature alloys are reported at National Research Corp., working with a new family of iron-aluminum-manganese alloys. One of alloys improves strength at temperatures above 1,200°F, has adequate oxidation resistance to 1,500°F, good machinability and cold working properties.

•

Development of high purity ductile vanadium metal with very low carbon content is important advance in low-carbon ferrochrome alloys. Alloys are marketed by Vanadium Corp. of America as EXLO 75.

•

New volatilizing flux permits brazing of Inconel X, other hard-to-braze materials in hydrogen or dissociated ammonia atmospheres. Available as powder or liquid, it is used with aircraft assemblies for high temperature service.

•

Cesium, according to National Geographic Society, is high on list of metals which may be used as propellant with ion rocket engine. Society points out that Cesium, which costs about $750 per lb, is easy to ionize with, say, a nuclear powered turbine.

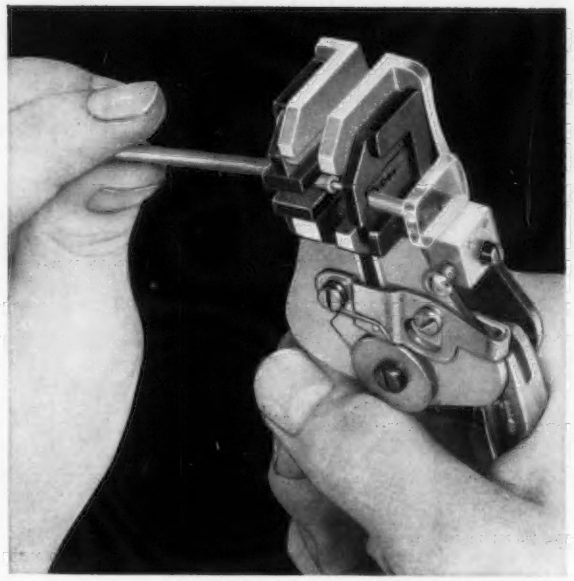
•

Office of Technical Services report cites method for synthesis of perarylated silanes making possible commercial production. High thermal stability of the compounds gives possible application to plastics and coating fields.

•

New vinyl-plastic-coated fabric is being used to absorb low frequency jet engine sounds. Cotton or fiberglass fabric is spread coated with a vinyl plastisol containing powdered lead.

continued on page 78



Just One Squeeze with IDEAL's New "Custom Stripmaster" Removes Teflon* and Other Hard-to-Strip Insulations

To help prevent wire nicking and insulation damage, these new IDEAL "Custom Stripmasters" are precision drilled on watchmaker's equipment.

With Ideal's new Custom Stripmasters, a light squeeze on the handles strips any wire completely clean and bare up to a full ⅞ inch.

To help prevent nicking and scraping of wires, the Custom Stripmaster's matched sets of blades are precision drilled on watchmaker's equipment to the exact wire sizes. Counterbored blades ride on cut insulation to prevent scratching of stripped wire. Jaws grip wire firmly to prevent insulation damage. 3 models available. Wire sizes from No. 10 to 30.

*Reg. Trademark of DUPONT

Custom Stripmaster® Patented, No. 2,523,936 by IDEAL

IDEAL INDUSTRIES, Inc.
1390-B Park Avenue, Sycamore, Illinois

Gentlemen: Please send catalog information on IDEAL's New "Custom Stripmaster."

Name_____

Company_____

Address_____

City_____ Zone____ State_____

Circle 30 on Inquiry Card, page 83

BALLYMORE
"Hi-boy" LADDERS

have exclusive PYRAMID design and automatic BALLYLOCK floor locking

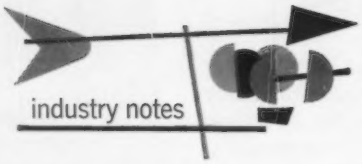
ALL-WELDED STEEL FOR REACHING HEIGHTS UP TO 15 FEET

For complete information, write:
BALLYMORE COMPANY
WEST CHESTER 27, PA.

BALLYMORE
EQUIPMENT FOR ABOVE-FLOOR SAFETY

LOOK FOR THIS LABEL TO BE SURE IT'S THE BEST

Circle 31 on Inquiry Card, page 83



MERCURY ORBIT . . .
. . . LOSERS' OBIT

Plans for the first U. S. manned satellite, which will be designed and produced by McDonnell Aircraft Corp. winner of NASA space capsule contract:

Schedule: at least two years work at costs of over $15-million.

Orbiting position: 100 to 150 miles from earth.

Accessories: Food, water, optical devices for viewing earth, couch, retro rockets.

Orbiting time: about 24 hours before parachute - aided return.

Some 600 McDonnell employees are slated to work on the project, dubbed "Mercury." McDonnell officials said no outside help is planned.

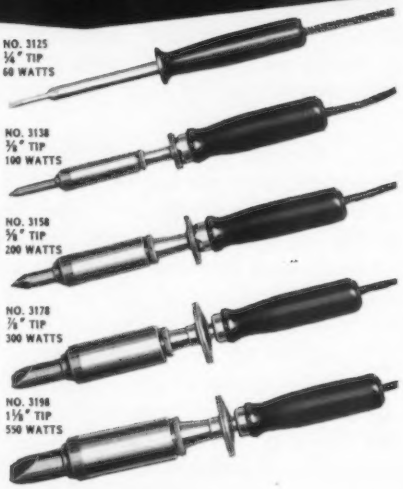
Award to "little" McDonnell Aircraft came as a surprise to many. Space age giants in the competition included North American Aviation, General Electric MSVD, Boeing, and Convair Astronautics.

In the pre-contract competition, Boeing had joined forces with Chance-Vought as a "design team." General Electric's nose - cone - wise Missile and Space Vehicle Department formed a similar team with North American. On Long Island, Republic, Grumman, and Fairchild joined forces. Odds were that one of these "teams" would get the coveted prestige contract.

Soldering is EASIER FASTER BETTER
with American Beauty Soldering Tools

American Beauty electric soldering irons are the highest quality made. The finest engineering, best materials and on-the-job experience since 1894 is yours with every American Beauty. There is a right model, correct tip size and proper watt input to do any soldering job easier, faster and better.

TEMPERATURE REGULATING STANDS
Automatic devices for controlling tip temperatures while iron is at rest—prevents overheating of iron, eliminates frequent retinning of tip, while maintaining any desired temperature. Available with perforated steel guard to protect user's hand.



201-B

WRITE FOR 28-PAGE ILLUSTRATED CATALOG CONTAINING FULL INFORMATION ON OUR COMPLETE LINE OF ELECTRIC SOLDERING IRONS—INCLUDING THEIR USE AND CARE.

AMERICAN ELECTRICAL HEATER COMPANY
DETROIT 2, MICHIGAN

American Beauty ELECTRIC IRONS SINCE 1894

Circle 32 on Inquiry Card, page 83

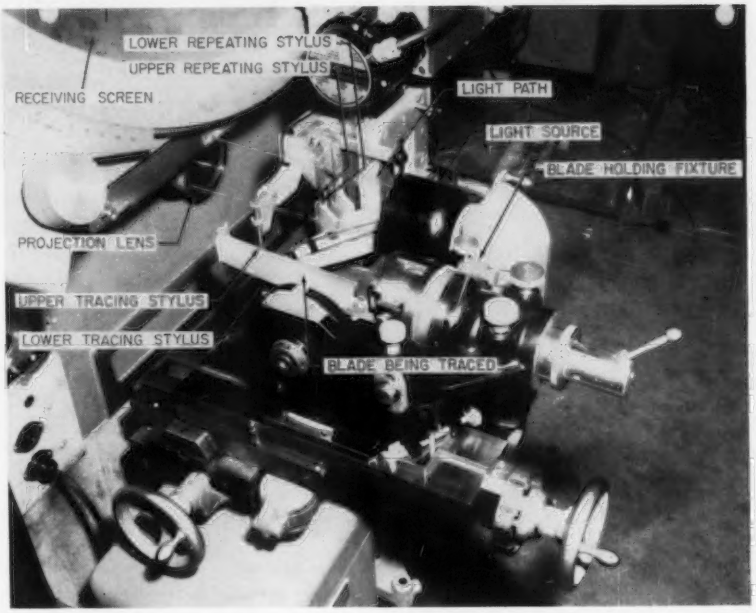
WHAT'S BURIED IN RED BUDGET?

The U. S. S. R. "visible military budget" shows a slight dip from last year. It amounts to about $24-billion. In terms of purchasing power, this is about equal to U. S. outlays.

Russian military spending, however, may actually be going up. Substantial increases are reportedly buried in the budget under headings such as "libraries" and "industrial expansion." Some $18-billion is budgeted for the latter.

Budget at a glance ($1 = 4 rubles): income, $180.8 billion; outgo, $176.9 billion; national economy, including industry costs, new construction, agriculture, $96.2 billion; social and cultural activities, $58 billion; defense, $24 billion; management of state programs, $2.8 billions.

OPTICAL TRACING



Jet blade is shown under precise optical inspection. Lens at left is part of Jones & Lamson optical comparator which sights and projects motions of each repeating stylus, thus tracing blade form. Repeating styluses are coordinated with an upper and lower tracing stylus, which maintain electrical arc with blade surface. This proximity tracing system, also being marketed by firm, uses special electronic servo-drive.

Leading missile manufacturers use
KOHLER
PRECISION CONTROLS

The complete Kohler line includes valves and fittings for aircraft, automotive and industrial uses—manufactured with superior facilities by an experienced organization under unified supervision. Our engineers develop controls to specifications for volume production. Write for information.

Check Valves:

Connections:
MS-33514 Flareless tube and gasket seal
MS-24385 Flared tube and gasket seal

Operating Pressure:
1500 PSI and 3000 PSI

Proof Pressure:
2250 PSI and 4500 PSI

Burst Pressure:
4500 PSI and 7500 PSI

Temperature Range:
-65° F to 275° F

Material:
1500 PSI Aluminum
3000 PSI Stainless Steel

KOHLER CO. Established 1873 KOHLER, WIS.
KOHLER OF KOHLER
Enameled Iron and Vitreous China Plumbing Fixtures • Brass Fittings
Electric Plants • Air-cooled Engines • Precision Controls

Circle 33 on Inquiry Card, page 83

Electrolytic Metal Removal

Potential Unlimited

This new procedure has solved hitherto unsolvable problems, and greatly increased capacity and quality in virtually every application.

As pioneers in this very "young" development, we can offer you real help in licking hard metal removal problems, with actual installation and performance data. **WRITE TODAY!**

Results depend on the spindle used. There is nothing finer in its field than a STANDARD Super Precision Spindle . . . available for electrolytic application in 50 to 3000 Amperes.

THE **STANDARD**
ELECTRICAL TOOL CO.
Precision Spindle Division
3000 River Road Cincinnati 4, Ohio

Circle 34 on Inquiry Card, page 83

NEW GIANT narda SONBLASTER

Generator G-5001
500 watts output

Transducerized Tank NT-5001
Capacity: 10 gallons
Dimensions: 20" L x 11½" W x 10" D

Generator features tank selector and load selector switches on front panel to operate one or two NT-5001 tanks alternately. Other combinations of tanks and submersible transducers available from stock; larger tanks available on special order.

$1325

For mass-production cleaning and high capacity chemical processing!

Here's a new Narda SonBlaster ultrasonic cleaner with tremendous cavitation activity and generating capacity! Featuring full 500 watts output, this SonBlaster is available with a fully transducerized giant 10-gallon capacity tank. In addition, it will operate from six to 10 Model NT-605 high energy submersible transducers, at any one time, in any arrangement in any shape tank you need up to 70-gallon volume.

Install this new Narda SonBlaster, and immediately you'll start chalking up savings over costly solvent, vapor or alkaline degreasing methods! You'll save on chemicals and solvents, cut maintenance and downtime, eliminate expensive installations, save on floor space, and release labor for other work. But perhaps most important, you'll clean faster, cut rejects, and eliminate bottlenecks.

Whether you're interested in mass-production cleaning or degreasing of mechanical, electronic, optical, or horological parts or assemblies ...rapid, quantity cleaning of "hot-lab" apparatus, medical instruments, ceramic materials, electrical components or optical and technical glassware...or in speeding up metal finishing and chemical processing of all types—you'll find this new SonBlaster will do your work faster, better and cheaper. Write for more details now, and we'll include a free questionnaire to help determine the precise model you need. Address: Dept. AMM-2u.

Consult with Narda for all your ultrasonic requirements. The SonBlaster catalog line of ultrasonic cleaning equipment ranges from 35 watts to 2.5 KW, and includes transducerized tanks as well as immersible transducers which can be adapted to any size or shape tank you may now be using. If ultrasonics can be applied to help improve your process, Narda will recommend the finest, most dependable equipment available for immediate delivery from stock—and at the lowest price in the industry ($175 up)!

For custom-designed installation and unique electro-acoustic applications, including cleaning, soldering, welding, drilling and nondestructive testing, consult our subsidiary, Alcar Instruments, Inc., at the address below.

the narda ultrasonics corporation
625 MAIN STREET, WESTBURY, L. I., N. Y.
Subsidiary of The Narda Microwave Corporation

Circle 35 on Inquiry Card, page 83

industry notes

continued from page 75

New high-strength, precipitation hardening, stainless steel alloy is being used for first time in retaining rings made by Waldes Kohinoor Inc. Alloy, Armco Type PH 15-7 Mo, is highly corrosion resistant up to 1000°F.

•

Low-hydrogen nickel-manganese AC-DC electrode announced by All-State Welding Alloys Co., Inc., is intended for joining and wear-surfacing of austenitic manganese and carbon steels —especially where present practice is using stainless steel electrodes.

•

Silica gel is reportedly finding increasing use as drying agent. The chemical was used to take up respiratory moisture in capsule housing a mouse in Thor-Able tests. Small packages of it, attached to all openings on first and second stage engines of Vanguard, show humidity conditions by changes of color.

THE NEW TITAN "INSERTO"

THREADED INSERT or BUSHING DRIVER

• • • featuring primary and automatic secondary clutches for driving either self-tapping or regular inserts

Drives inserts to a very accurate position. Selective position is accomplished by a wide-range depth gage on the driver while driver is rotating. Depth gage is ball bearing mounted, eliminating marking of casting face.

"Inserto" has a primary clutch for driving and a secondary positive clutch for reversing out of insert after it is driven. When insert is driven to proper position, the primary (drive) clutch disengages. When the motive power is pulled back to actuate the automatic reverse, the secondary clutch engages and the "Inserto" rapidly reverses out of the predriven insert.

"Inserto" can easily be used with a tapping head mounted on an ordinary drill press; or with automatic air or electric tapping motors when provision is made to keep the tool spindle at right angles to face of casting.

Sizes available: No. 1, Cap. #10 to ⅜" I.D.; No. 2, Cap. ⅜" to 18 I.D., or ⅝"—16 female driving thread; also ⅜" or ½" female square drive.

Write for details and prices today!

TITAN TOOLS
World's Largest Producers Of Stud Drivers And Pullers
TITAN TOOL CO.
48 MAIN ST., FAIRVIEW (ERIE COUNTY), PA.

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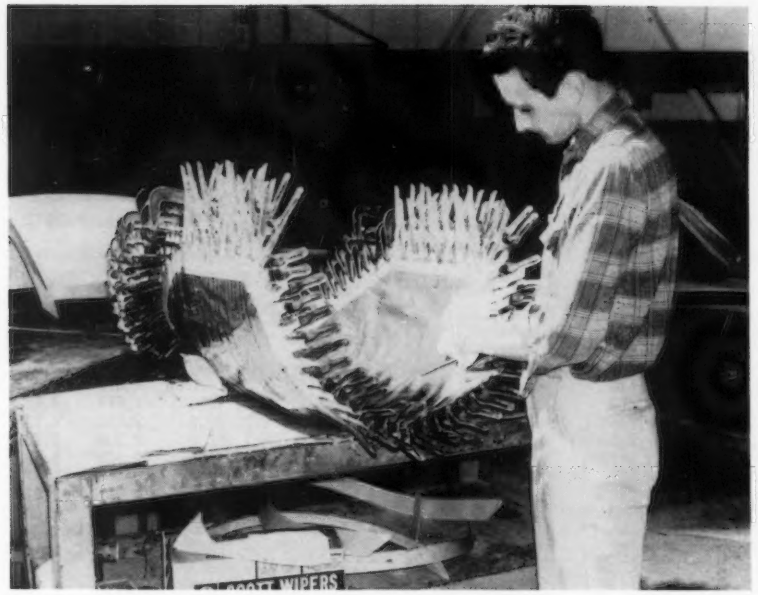
PAPER & PLASTIC



Lint on partially-completed Plexiglass cockpit enclosure would appear as speck when plastic enclosure is hardened and finished. Here a worker in Douglas Aircraft's Plastics Department uses Scott Paper Co. two-ply absorbent paper wiper to take excess bonding agent from enclosure for F4D-1 "Skyray."

TOLERANCE
20
1,000,000"

DO YOU NEED PIECES GROUND TO THIS TOLERANCE?

LaVezzi has specialized for over 50 years in the manufacture of small machine parts requiring varied operations, all to extremely close tolerances and fine finishes. Included are items held to tolerances shown above, in both production and prototype quantities. We invite your quote requests and are anxious to place our facilities at your disposal. Write today for illustrated brochure!

LaVezzi MACHINE WORKS
4635 WEST LAKE ST., CHICAGO, ILLINOIS

Circle 37 on Inquiry Card, page 83

Aeroquip
WEBLOCK
Straps

SIMPLIFY HANDLING OF ROCKET THRUST CHAMBERS AT ROCKETDYNE

Thrust chambers are palletized for handling.

Use of Aeroquip WEBLOCK Strap Assemblies can solve many materials handling problems. At Rocketdyne, division of North American Aviation, Inc., a simple nylon strap harness was developed to secure top-heavy rocket thrust chambers on pallets. Harness attachment is quick and easy. Tension is automatically locked with a pull of the WEBLOCK Strap, released with finger touch.

Outline your aircraft or missile tie-down requirements and let General Logistics provide simple, low-cost answers. Mail coupon below for details.

Ratchet Tie-Down Buckles

WEBLOCK Strap Assemblies

General LOGISTICS
A DIVISION OF Aeroquip CORPORATION

2929 Floyd Street, Burbank, California
Please send information on: AMM-2
☐ Ratchet Buckle ☐ WEBLOCK Straps
NAME
TITLE
COMPANY
ADDRESS
CITY STATE

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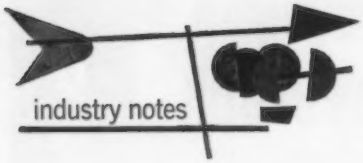


INDUSTRY STATISTICS

Source: Bureau of the Census and Civil Aeronautics Administration.

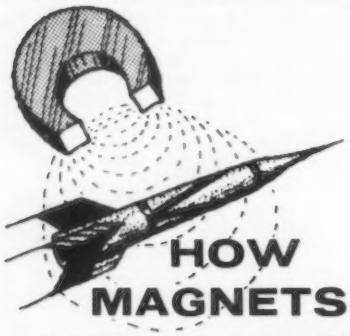
NUMBER AND VALUE OF CIVIL AIRCRAFT SHIPMENTS

Month	Units		Value in Thousands	
	1958	1957	1958	1957
January	579	584	$ 62,311	$ 48,431
February	510	523	65,046	49,278
March	697	675	35,133	46,636
April	704	657	47,496	57,980
May	622	672	35,113	84,136
June	589	590	25,455	69,497
July	503	525	41,587	70,649
August	471	519	30,776	62,990
September	399	466	24,401	54,911
October	628	474	49,328	45,687
November	531	516	34,881	47,213
December	.....	544	.....	44,856
Total—Year	.....	6,745	.....	$682,264
Total—11 Mos.	6,233	6,201	$451,527	$637,408

AIRFRAME WEIGHTS OF CIVIL AIRCRAFT SHIPMENTS

Month	Thousands of lbs.		Avg./Aircraft	
	1958	1957	1958	1957
January	1,909.9	1,574.9	3,299	2,697
February	1,891.4	1,554.0	3,709	2,971
March	1,313.2	1,625.6	1,884	2,408
April	1,606.4	1,886.6	2,282	2,871
May	1,293.4	2,558.0	2,079	3,806
June	1,068.1	2,114.0	1,813	3,583
July	1,418.7	2,096.0	2,820	3,992
August	1,106.0	1,950.6	2,349	3,758
September	855.2	1,641.1	2,143	3,522
October	1,545.6	1,456.5	2,461	3,073
November	1,107.1	1,480.8	2,085	2,870
December	.....	1,430.8	.....	2,630
Total—Year	.....	21,368.9	.....	3,168
Total—11 Mos.	15,115.0	19,945.3	2,425	3,216

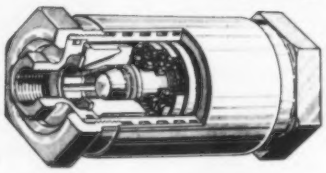
NEXT MONTH
Look for the Missile Handbook!



HOW MAGNETS help keep missiles and aircraft flying

FERRO FILTER®

Magnetic Separators



protect fluid power systems of missiles and aircraft by removing even microscopic ferrous particles that can jam delicate, precision-made, hydraulic equipment. Shown above: Model PX-2; dry weight only 3 lbs; 3000 psi working pressure; tapped for ½" tube connection, AND-10050.

Send for BULLETINS PM-37 and PX-2

S. G. FRANTZ CO., Inc.
Brunswick Pike & Kline Ave.
P. O. Box 1138 Trenton 6, N. J.

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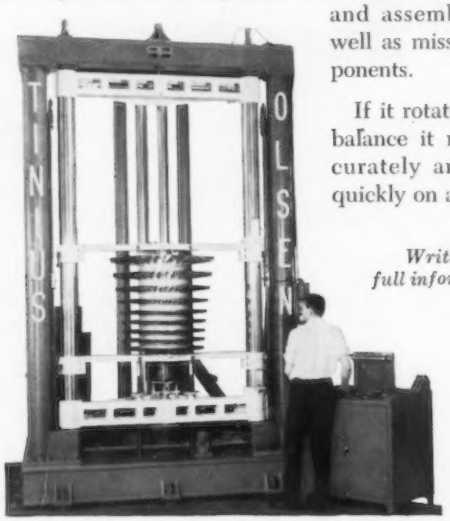
BALANCING JET ENGINES ?

Tinius Olsen offers the most complete line of static *and* dynamic balancing machines for jet engine stages and assemblies, as well as missile components.

If it rotates, you'll balance it more accurately and more quickly on an Olsen.

Write for full information.



TINIUS OLSEN
Testing Machine Co.
2210 Easton Rd. • Willow Grove, Pa.

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SHIPMENTS OF PISTON ENGINES FOR CIVILIAN AIRCRAFT

Month	Units 1958	Units 1957	Value 1958	Value 1957
January	1,033	920	$ 8,883,000	$ 12,445,000
February	1,139	902	9,696,000	13,596,000
March	994	1,010	8,174,000	13,975,000
April	881	950	8,174,000	14,388,000
May	828	1,020	6,176,000	15,160,000
June	783	933	5,994,000	15,636,000
July	730	801	4,898,000	12,748,000
August	693	776	3,420,000	8,603,000
September	757	728	3,312,000	10,150,000
October	811	921	3,336,000	13,638,000
November	786	878	2,815,000	9,880,000
December		1,020		12,237,000
Total—Year		10,859		$152,456,000
Total—11 Mos.	9,435	9,839	$ 64,878,000	$140,219,000

TOTAL HP. OF AIRCRAFT PISTON ENGINE SHIPMENTS FOR CIVILIAN USE

Month	Total Hp. (in Thousands) 1958	Total Hp. (in Thousands) 1957	Avg. Hp. per Engine 1958	Avg. Hp. per Engine 1957
January	459.9	604.4	445	657
February	518.2	647.0	455	717
March	440.7	679.2	443	672
April	428.0	668.2	486	703
May	338.3	715.8	409	702
June	328.7	730.4	420	783
July	282.1	590.4	386	737
August	210.0	425.6	303	548
September	214.0	482.8	283	663
October	220.9	628.3	272	661
November	198.0	473.0	252	539
December		586.2		575
Total—Year		7,231.3		666
Total—11 Mos.	3,638.8	6,645.1	386	675

EMPLOYMENT IN THE AIRCRAFT AND PARTS PLANTS

Month	Complete Aircraft Plants 1958	Complete Aircraft Plants 1957	Aircraft Engine and Parts Plants 1958	Aircraft Engine and Parts Plants 1957	Aircraft Propellers and Parts 1958	Aircraft Propellers and Parts 1957
January	457,500	533,800	156,600	185,200	20,800	19,700
February	455,300	540,300	154,000	188,400	20,600	20,100
March	457,800	541,200	152,400	189,200	20,300	20,400
April	456,600	541,300	152,300	188,400	19,800	20,600
May	445,500	542,800	151,600	184,800	19,300	20,500
June	454,200	541,000	151,700	184,000	18,800	20,700
July	455,900	539,100	151,300	182,100	18,000	21,000
August	458,900	528,100	150,900	178,200	17,200	20,500
September	458,500	515,900	153,700	174,900	16,900	20,600
October		503,700		170,600		20,700
November		477,000		163,200		20,200
December		463,900		160,200		20,400
Avg.—Year		522,300		179,100		20,500
Avg.—9 Mos.	455,600	535,900	152,700	183,900	19,100	20,500

UNFILLED ORDERS OF AIRCRAFT FOR CIVILIAN USE

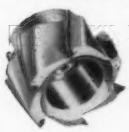
Month	1958	1957
January	732	997
February	707	992
March	684	985
April	670	966
May	660	947
June	654	900
July	705	854
August	693	808
September	673	783
October	666	757
November	653	782
December		761

For increased production and better finish!

HELICARB

HELICAL CARBIDE CUTTERS

Now standard in these types!



Shell mills

End Mills and Adapter

Staggered-tooth Side Mills

Interlocking Side or Straddle Mills

Slab mills

Write for catalog and name of your nearest distributor.

Special tools designed with "Helicarb" principle.

SONNET

TOOL AND MANUFACTURING COMPANY

571 North Prairie Avenue, Hawthorne, California

The original line of standard Helical Carbide tools

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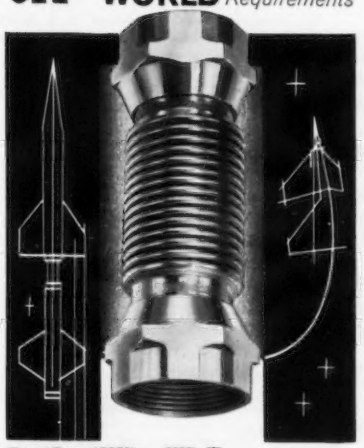
up to OUT-OF-THIS WORLD *Requirements*



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STAINLESS DUCTS and BELLOWS

- Handle high temperature corrosives
- Withstand drastic pressure changes, vibration and sinuous alignment

WRITE TODAY FOR TECHNICAL DATA

U.S. FLEXIBLE TUBING CO.

213 MAIN STREET, BARTLETT, ILL.

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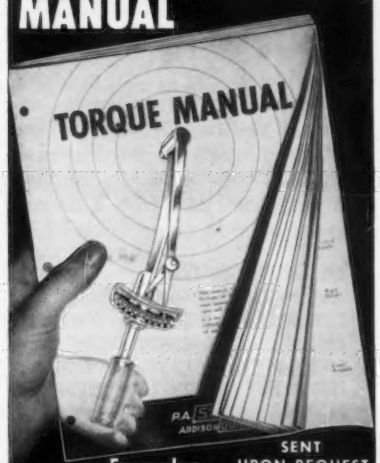
"TORQUE WRENCH" MANUAL



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Formulas

Applications

Engineering Data

Screw Torque Data

Adapter Problems

General Principles

P.A. STURTEVANT CO.

ADDISON QUALITY ILLINOIS

Manufacturers of over 85% of the torque wrenches used in industry

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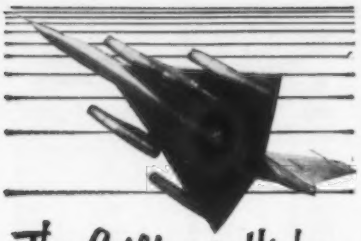

The Ceiling is Higher

in opportunity, too

. . . at GE's

JET ENGINE DEPT. in CINCINNATI

If you like to meet and solve new problems . . . if you like the challenge of the unknown . . . if you're a man who likes to help write tomorrow's textbooks in today's test labs . . . if you don't know that "it can't be done that way" . . .

you'll like it at GE . . . where a man's ability is recognized and rewarded.

Our unique use of small-unit work groups emphasizes and encourages creative freedom. Our engineering staff has more than doubled since 1955, and annually about 50% of our engineers have been promoted.

Right now the high energy fuel jet engine of the future is being developed. Top men in the industry want you to join them in this exciting pioneering at General Electric. Career positions for *Degree Engineers with U. S. Citizenship* are open in many fields—

RELIABILITY ANALYSIS . . . AERODYNAMIC DESIGN—COMPRESSORS, TURBINES . . . ELECTRICAL CONTROLS DESIGN . . . ADVANCED ENGINE PERFORMANCE ANALYSIS . . . ENGINE FLIGHT TEST . . . CONTROL COMPONENT DESIGN . . . COMBUSTION SYSTEMS DESIGN . . . ENGINE MECHANICAL COMPONENT DESIGN and many others.

Send your resume—or, for more information, write or phone:

Mark Elwood, General Electric Co.
Jet Engine Dept. AMM-2
Cincinnati 15, Ohio
Phone POplar 1-1100

Collect long distance calls will be accepted any weekday 9 A.M.-4 P.M.

GENERAL ELECTRIC

Circle 44 on Inquiry Card, page 83

your date book

february 3-5
14th annual technical
and management conference
reinforced plastics div.,
society of the plastics industry
edgewater beach hotel, chicago

◆

february 12-13
computer and data processing
conference for manufacturing
and engineering management
purdue university
lafayette, ind.

◆

february 26-march 1
1959 engineering exposition
balboa park
san diego, calif.

◆

march 3-5
1959 western joint
computer conference
institute of radio engineers,
american institute of
electrical engineers,
assn. for computing machinery
fairmont hotel, san francisco, calif.

march 8-11
fourth annual gas turbine
conference and exposition
gas turbine power division,
a. s. m. e.
the netherland hilton,
cincinnati, o.

◆

march 16-20
11th western metal
exposition and congress
american society for metals
pan pacific auditorium,
ambassador hotel, los angeles, calif.

◆

march 25-27
16th annual conference
pacific coast section,
society of the plastics industry,
hotel del coronado, san diego, calif.

◆

march 31-april 3
national aeronautical meeting
society of automotive engineers
hotel commodore, n. y., n. y.

◆

april 18-22
annual meeting
american society of tool engineers
schroeder hotel, milwaukee, wisc.

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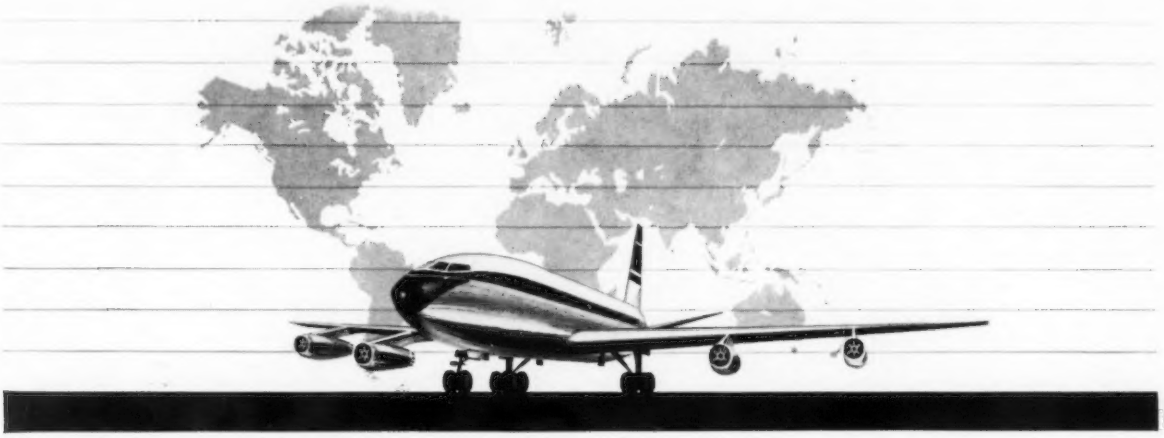
Amchem Alodine... industry standard for the jet age

...chemical conversion coatings for aluminum



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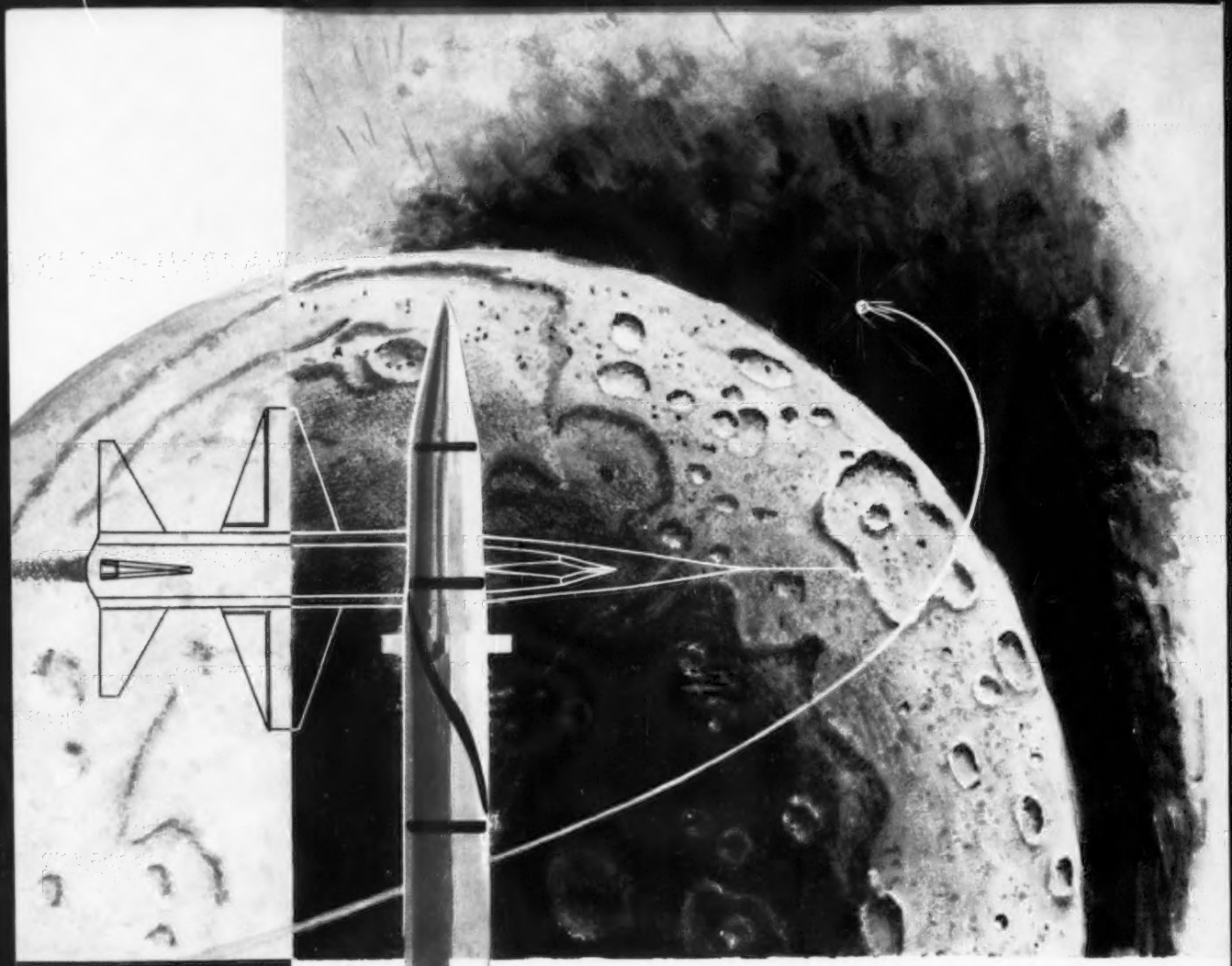

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